SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

APRIL 1898.

GENERAL PHYSICS.

356. *Specific Cohesion of Metals.* **R. Herzfeld.** (Annal. Phys. Chem. 62. pp. 450–453, 1897.)—Drops of various metals were prepared by making a piece of the metal the positive pole of an electric arc, on a carbon plate. The dimensions of the solidified drops gave the specific cohesions. The results showed that the specific cohesions of copper, iron, nickel, and cobalt are three times that of mercury, and they must therefore be classed in Quincke's third group. E. E. F.

---

357. *Sprengel Pumps and Röntgen Tubes.* **G. Guglielmo.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 324–331, 1898.)—A paper on practical points as to construction of the above. A. D.

---

358. *Pump for delivering Liquids Air-free.* **P. de Senevoy.** (Comptes Rendus, 126. pp. 224–225, 1898.)—The author describes and figures a pump which can conveniently be adapted to bottles, for the purpose of removing the contents of the bottle, as required, without allowing the inflow of air.

R. A. L.

---

359. *Upper Atmosphere.* **L. Cailletet.** (Paris Soc. Franç. Phys., Bull. 108. pp. 4–5, 1898.)—Experiments are described for testing Laplace's law as to the density of the atmosphere at high elevations by sending, from balloons already at a considerable height, pilot balloons bearing automatic photographic apparatus. This apparatus photographs simultaneously, and at regular intervals, the face of a sensitive aneroid barometer and a view of the surface of the earth beneath. The latter being identified and distances on it measured, this gives the elevation. The other photograph

shows the simultaneous indication of the barometer. **M. A. Leduc** said, *à propos* of the above, he had recently found the air at 1650 metres above Paris contained the same amount of oxygen as the air in Paris, 0·232 (from 0·2318 to 0·2323). A. D.

---

360. *Deformations on Stretching Metals.* **G. A. Faurie.** (Comptes Rendus, 126. pp. 400–401, 1898.)—A long rod of copper, for example, is softened by heating; it is then stretched with a force of 22 kg. per sq. mm.; the load is then removed. The hardening ("écrouissage de traction") is again removed by heat, etc. That is to say, the bar goes through the same cycle of operations again and again. After two or three cycles the rod develops an appearance resembling the nodes and ventral segments of a vibrating wire, equidistant swellings being separated by corresponding depressions. The author suggests that the phenomenon is due, in some way, to interference between the effects of the terminal clutches. A. Gs.

---

361. *Determinations of Length by Interference.* **R. Benoît.** (Journ. de Physique, 7. pp. 57–68, 1898.)—With the help of the interference-bands of three cadmium lines (red, green, blue), Michelson in 1893 succeeded, in the laboratory of the Bureau International, to express the length of a metre in terms of wave-lengths. In the well-known apparatus, ray S is normal to mirror D, mirror A under 45° to AS; D′, the image of D in A, forms the plane of reference; C is parallel to D′ between A and D, and B, the compensator, parallel to A, intermediate between A and C. All the mirrors are plane; B can be turned about its horizontal axis. This arrangement is now used by Benoît for standardising millimetres and centimetres. Interference was produced by two of the several possible methods. In the one case, C and D′ are not quite parallel, when bands are observed; in the other, the distance CD′ is varied, when rings are noticed. For his determination, he used a polished nickel rule of 1 cm. divided in mm., and further a so-called Michelson standard, replacing Michelson's intermediate standard. A bar of bronze, 2 cm. square, 12 cm. long, has on its one end two steps, on which two four-sided glass prisms MM′ are standing, as nearly as possible 1 mm. apart. In measuring this distance accurately, the chief task is, after Michelson's work, to determine the "excédent fractionnaire" of the respective distance over a whole number of half-wave-lengths, that fraction showing which one of a series of determinations (115 were taken) of the different whole numbers with their different decimals is to be chosen. For this purpose, D′, M, M′ must all be parallel; D′ being larger than the other two, the plane of reference is projected simultaneously on both M and M′, and both show bands. Then follows the comparison of the MM′ distance as determined with the rule which is placed on the top of the bronze bar and viewed by a microscope (power 300). This microscope, the author

considers, is the chief source of error. Vacuum-tubes with a piece of cadmium, wrapped in copper, an induction-coil, and a carbon-bisulphide prism, gave the light. In addition to the three rays on which Michelson relied, Benoît also used a violet line for some of his experiments. The various determinations differ by $\pm 0{\cdot}006\,\mu$; the agreement with Michelson's values is slightly less perfect. The paper is illustrated by two small diagrams only. Chappuis is now determining the mass of a cubic decimetre of water by the Michelson-Fizeau method. H. B.

---

362. *Bending of Thick Plates.* **Ribière.** (Comptes Rendus, 126. pp. 402–404, 1898.)—A mathematical treatment is given on the magnitude of the stresses in a *thick* plate, supported in various ways and subjected to a load. The results differ strikingly from those obtained by the usual method of treating a beam as consisting of longitudinal filaments to a large extent independent of one another. A. Gs.

---

363. *A Photographic Impact-testing Machine.* **B. W. Dunn.** (Frank. Instit. Journ. 144. pp. 321–348, 1897; 145. pp. 36–47, 1898.)—The apparatus consists of an anvil, the cylindrical test-piece, a steel piston resting upon it, a mirror attached to the piston, a falling weight, a tuning-fork, and a revolving drum on which a magnified photographic record is obtained. The magnification depends upon the distance between mirror and drum. A hole is bored in the end of the tuning-fork, between which and the sensitised surface a lens is interposed, producing an image moving up and down on the drum which revolves about its vertical axis. By placing a fine wire in the path of the reflected ray, the band of two intersecting curves is broken up into dark and light horizontal strips. This novel arrangement admits of measuring a time-interval of $1/10^7$ sec. The small mirror turns about a fixed horizontal axis, and is connected with the piston by link-work. No further details are given concerning this important part, the mirror, which is to revolve at a rate depending entirely upon the rate of the piston.

The record-drum was first moved by an electric motor, which was, however, replaced by a system of cog-wheels and a weight of 100 lb. attached to a cord passing over a winding-drum. As high-frequency tuning-forks vibrate for a short period only, the following arrangement was adopted. The operator releases the 100 lb. weight, the photographic drum begins to spin, and the weight actuates a trigger, pulling a pin which allows the mass to fall. At the same moment an electric circuit is broken, and two shutters begin to drop. A few thousandths of a second before the mass strikes the piston, the photographic drum is disconnected from its gearing, and continues to revolve with uniform velocity; the wedge is pulled out of the tuning-fork. The mirror being as yet stationary, the sunlight (admitted through two pipes into the dark om) traces an abscissa on the drum. When impact occurs, a brilliant line of light, almost vertical, is seen to flash up the drum; this line shows the compression of the copper test-block on first impact. There follow rebounds, and a wave of elastic compression preceding the permanent set. A mass of 33 lbs. falling through 15 in. produced a permanent compression of 0·1658 in. within 0·0020317 sec.; the rebound was about 0·002 in. It results that the dynamic curve which we really wish to determine when the behaviour of materials exposed to sudden blows is to be examined, differs little only from the static curve corresponding with a slowly applied force. Although Dunn's anvil is made of Harveyised nickel-steel, J. R. Johnson's objection that the yielding of the anvil would introduce errors seems well founded. H. B.

364. *Method of obtaining Capillary Pores of specified Diameter.* **C. Barus.** (Phys. Rev. 6. pp. 52–54, 1898.)—A rubber tube, whose walls are $\frac{1}{32}''$ to $\frac{1}{8}''$ according as coarser or finer pores are wanted, is perforated radially with holes, disposed as nearly together as possible, from end to end of the tube. The puncturing is effected by a comb composed of about 50 equidistant cambric needles lying in the same plane, which is actuated by a mechanism similar to a screw copying-press; with this it is possible to pierce between 5000 and 10,000 holes per linear metre of the tube. After the needles are withdrawn, the holes close almost completely and are almost invisible to the unaided eye. A tube made radially porous in the above manner is a valve of a peculiar kind, so that if there is an excess of pressure on the inside the tube will enlarge, and the pores open proportionally. To use this device for obtaining pores of a specified diameter, the punctured tube is axially surrounded by a cylindrical wide glass tube. One end of the rubber tube is closed, and the other provided with a tubulure with stopcock and pressure-gauge for admitting gas (or turbid liquid to be strained) to the interior of the perforated tube. A similar tubulure is provided to the outer glass tube for water, as also an efflux tubulure. To calibrate this, it is necessary to allow gas to enter the perforated tube under pressure, and water the outer tube, and to observe the pressure excess of the gas gauge over the liquid gauge when bubbles first begin to appear. The author points out that if a perforated rubber tube be filled with water, and hung up closed at both ends in air, the water will gradually evaporate as through unglazed porcelain and the tube partially collapse, owing to the external pressure of the atmosphere. E. C. R.

LIGHT.

365. *Ultra-Violet Spark Spectra.* **F. Exner** and **E. Haschek.** (Wien. Akad. Sitzber. 106. pp. 336–356, 1897.) (For previous papers see Phys. Soc. Abstracts, 1896, No. 449, and 1897, Nos. 73, 301, 302, 526, 653.)—*Cobalt and Nickel.* It is remarkable that in the spectra of Co and Ni strong lines of equal or nearly equal intensity appear identically: *e. g.* line 3619·52 ($i=1$) appears in Ni, and line 3619·55 ($i=2$) appears in Co. Such coincidences are still more frequent in the weaker lines, as already shown by the measurements of Hasselberg, who also called attention to the fact that the lines of Ni and Co varied in intensity under different conditions, pointing to the presence of a third constituent. The pairs 3274·13 ($i=3$) in Ni, and 3274·10 ($i=2$) in Co: 3247·72 ($i=2$) in Ni, and 3247·70 (1=2) in Co, correspond with the two strongest lines of Cu, viz. 3274·09 and 3247·68. At the same time contamination by Cu is rendered improbable by the absence of its other lines.

Tellurium. Measurements of 256 lines between $\lambda=4689{\cdot}0$ and 2142·6 AE. Iron was absent.

Mercury. Measurements of 119 lines between $\lambda=4358{\cdot}7$ and 2224·9 AE.

Bismuth. 85 lines between $\lambda=4722{\cdot}8$ and 2187·1 AE.

Antimony. 186 lines between $\lambda=4693{\cdot}2$ and 2289·1 AE.

Carbon. The difficulty of obtaining the element in an absolutely pure, dense, and conductive form has not been overcome. The materials available were Siberian graphite, gas carbon, crude or compressed, and Moissan's "Carbone sublimé"—all more or less impure. The lines of cyanogen, from the union of the C with the N of the air, also occasionally appear. Measurements of the different spectra are given. S. G. R.

366. *Telemetrical Focometer.* **W. Stroud.** (Phil. Mag. 45. pp. 91–98, 1898.)—This paper contains a description of an instrument designed to detect whether an object or image is at a distance from it greater or less than a specified range. Two images of the object are obtained, one from each end of the base of the instrument, and are viewed simultaneously in the field of view of the eye-piece. These images are brought into coincidence by shifting the instrument along the optical bank to or from the object. The instrument is used exactly as a short-focus telescope; it is, however, much more accurate than the latter and much more easy to use. AUTHOR.

367. *Rotatory Power in Liquids, and Temperature.* **P. A. Guye** and **E. Aston.** (Comptes Rendus, 125. pp. 819–821, 1897.)—Generally, the specific rotatory power of a fluid diminishes with rise of temperature, there being no discontinuity in passing from the

liquid state to that of vapour. The rotatory power does not appear to tend towards a limiting value on raising the temperature. There are, however, some exceptions to these laws. For example, the rotatory power of amyl alcohol first falls, and then rises, on raising the temperature. This anomaly may be merely apparent. The vapour of amyl alcohol consists of simple molecules of the formula $C_5H_{12}O$. But in the liquid state, the capillary measurements of Ramsay and Shields show that molecular complexes $(C_5H_{12}O)_n$ exist, the proportion of the latter decreasing with rise of temperature. The phenomenon may therefore be explained by assuming that the simple molecules have a higher rotatory power than the complexes. If that is so, dissociation brought about by means other than heat ought to affect the rotatory power. This is found to be the case. Thus an aqueous solution of the alcohol has a higher rotatory power than a solution in benzene. W. R. C.

368. *Rotatory Power of Polymers.* **Berthelot.** (Comptes Rendus, 125. p. 822, 1897.)—In support of the assumption put forward in the preceding Abstract, Berthelot observes that the rotatory power of isoterebenthene, $C_{10}H_{16}$, is $-10°\cdot0$, while for metaterebenthene, $C_{20}H_{32}$, it is $-3°\cdot3$. Similarly for styrolene it is $-3°\cdot4$, and for metastyrolene it is $-2°\cdot2$. W. R. C.

369. *Lambert's Law and Polarisation.* **W. von Uljanin.** (Annal. Phys. Chem. 62. pp. 528–542, 1897.)—This work, which is on lines similar to that of Millican, deals with the theory of the polarisation of light by dull and by polished surfaces. The author shows that all the observed phenomena are explained by the laws of refraction of light which emerges from the body into the air. E. E. F.

370. *Mean Horizontal Candle-Power of a Glow-Lamp.* **C. P. Matthews.** (Phys. Rev. 6. pp. 55–57, 1898.)—The author makes a careful comparison of two different methods of determining the mean horizontal candle-power of a glow-lamp.

(1) Finding the mean radius of the candle-power distribution-curve.

(2) Whirling the lamp about a vertical axis of symmetry at such a speed as to eliminate flickering.

He obtains the value 9·655 for (1), and 9·649 for (2). The obvious conclusion is that the two methods lead to the same result when there is no colour-difference. E. C. R.

371. *Photographic Objectives.* **M. v. Rohr.** (Zeitschr. Instrumentenk. 18. pp. 4–12, 1898.)—The author shows that distortion is not obviated by making the emergent rays parallel to the incident, and therefore it is not obviated by symmetrical lenses. A full historical sketch is given, in which it is shown that English and American opticians were to the fore in the theory of distortion. A. D.

372. *Spectro-Photometer*. **H. Krüss.** (Zeitschr. Instrumentenk. 18. pp. 12–18, 1898.)—A photometer is described, with a Lummer-Brodhun pair of prisms, for comparison both of total light and of each spectrum component. A. D.

373. *Glow-worm Rays*. **H. Muraoka** and **M. Kasuya.** (Annal. Phys. Chem. 64. pp. 186–192, 1898.)—The photographic effect of glow-worm light, apparently exerted through a black-paper covering, is not solely due to the rays shed by the insects, but partly at least to some influence of vapours proceeding from them. Similar photographic effects are caused by moist brown paper, resin, and coffee. Zinc, magnesium, and cadmium exert a similar influence, but mica or glass stops it. An experiment made with cadmium oxide still awaits explanation. A small square was cut out of a sheet of stout cardboard. The square was filled with powdered cadmium oxide. Another piece of cardboard, with a larger square cut out of it, was laid upon the first. A sensitive plate laid on the top was only blackened to the extent of the smaller square, and the blackening could be stopped by the insertion of a piece of copper. E. E. F.

374. *Röntgen Rays and Vegetable Life*. **G. Tolomei.** (Roma, R. Accad. Lincei, Atti 7. 1. pp. 31–39, 1898.)—The result of many varied experiments is that the action of Röntgen rays on vegetable life, in respect particularly of the quantity of gas developed and of the effect upon the growth of bacteria, is the same as that of light, but weaker. A. D.

375. *Kathode Rays in an Alternating Electrostatic Field*. **H. Ebert.** (Berlin Phys. Gesell. Verh. 17. pp. 2–7, 1898.)—Preliminary discussion of the results of K. E. F. Schmidt as to the deflection of kathode rays by high-frequency alternating electric forces, and as to whether this is due (1) to the magnetic action of displacement currents in the dielectric, (2) to charges on the wall of the tube, or (3) to a special cause of kathode phenomena, the action of an external oscillating field upon the walls of the tube. Of these, (1) and (2) seem to be excluded, while (3) seems to be correct. Experimental details to be published later. A. D.

376. *Kathode Rays and Röntgen Rays*. **A. Battelli.** (Phil. Mag. 45. pp. 163–172, 1898.)—S. P. Thompson thinks there are, within Crookes tubes, a special kind of rays differing both from kathode and from Röntgen rays ('Electrician,' Jan. 8, 1897). From similar data the author and Prof. Garbasso have concluded that the Röntgen and the kathode rays are of an identical character with this difference, that the first only constitute a part of the latter. It cannot be asserted that the kathode rays are reflected as a whole according to the laws of regular reflection. Kathode rays reflected by the reflector of a focus tube can subsequently

undergo a new anomalous reflection similar to the first reflection of the same rays, and may be confidently assumed to possess the same properties as the direct kathode rays. The rays emanating from the posterior part of a very thin sheet, the anterior part of which is struck by the kathode rays, also possess the same properties as these; and the photographic effect of such rays is greater at the back of such a plate, the thinner the plate and the less dense its substance. The photographic action of the surface facing the kathode is the *more feeble* the less the thickness of the sheet. A pencil of kathode rays appears as if made up of various rays of different natures: when they strike on a substance of very small thickness, they seem to possess the power of passing through it, but in the same way as if they passed through a filter which would allow a passage more or less easy to some of them than to others. A. D.

377. *Discharge of Electrified Bodies by Röntgen Rays.* **C. D. Child.** (Phys. Rev. 5. pp. 193–212 and 285–293, 1897.)—After a *résumé* of articles published on the subject of discharge in gases generally, the author describes his own experiments on the relation between the rate of discharge and the density of the surrounding gas. The curve showing the relation of these is, for 35 volts and above, fairly in accord with Benoist and Hurmuzescu's statement that the rate of discharge is proportional to the square root of the density of the gas. At 6 volts the curve is quite different, and the rate of discharge presents a maximum at a pressure of about 200 mm. Hg. Again, a maximum rate of discharge presented itself, with Röntgen rays, when the pressure was 200 mm., the voltage 8 volts, and the distance between the plate and the surrounding metal 2 cm.; while with ultra-violet light the corresponding data for a maximum rate of discharge are 4½ mm., 100 volts, and 0·8 cm. A thin coating of paraffin on metal seemed to allow a discharge through it, not a mere condenser effect. The experimental results are shown to be in harmony with Thomson and Rutherford's theory (Phil. Mag. 42. p. 392) of the electrolytic conduction of electricity in a gas. The ionisation produced by an interrupted discharge seems to endure for about 0·1 second, and is more rapid when the pressure is low. A. D.

378. *Secondary Effect of Discharge by Röntgen Rays.* **J. Perrin.** (Comptes Rendus, 126. pp. 243–244, 1898.)—M. Sagnac's secondary rays, much absorbed by the first layers of air they encounter, produce in that air an ionisation analogous to that produced by direct rays. A. D.

379. *Influence of Röntgen Rays on Electric Spark.* **S. Guggenheimer.** (Comptes Rendus, 126. pp. 416–418, 1898.)—The maximum spark-length was measured between (1) two points, (2) one point and one disc, and (3) two balls when Röntgen rays

were traversing the spark-gap and when not. In every case an augmentation of spark-length was obtained by the use of the rays, the augmentation being greatest with the point and disc when the disc was the positive terminal. If the augmentation was due only to ionisation of the gas, it ought to be greatest when the disc is negative. There must therefore be another influencing factor, possibly the electric density on the negative pole.

Employing the transformed rays produced by passing Röntgen rays through fluorine, the author finds that the effect on the spark-length is increased by the transformation. J. B. H.

---

380. *Source of Röntgen Rays.* **J. Trowbridge** and **J. E. Burbank.** (Phil. Mag. 45. pp. 185–191, 1898; and Amer. Journ. Sci. 5. pp. 129–134, 1898.)—Kathode rays and Röntgen rays are given off from every element of a continuous conductor in a Crookes tube at a high vacuum, and this occurs both when the conductor constitutes the kathode and when it forms the anode of an electrical circuit. The so-called Röntgen-ray burn of the skin can be produced by an intense state of electrification. A. D.

---

381. *Phosphorescence by Electrification.* **J. Trowbridge** and **J. E. Burbank.** (Amer. Journ. Sci. 5. pp. 55–56, 1898.)—Action of Röntgen rays on fluorite is exactly similar to that of electrification, producing phosphorescence during the dissipation of an electric charge communicated. This phosphorescence is brighter and briefer if the fluorite be heated, the effect being to accelerate the dissipation of the charge. A. D.

---

382. *Röntgen Rays and Mineral Phosphorescence.* **J. E. Burbank.** (Amer. Journ. Sci. 5. pp. 53–54, 1898.)—Notes are given as to the phosphorescence of various minerals under Röntgen rays. 12 out of 16 calcium minerals phosphoresced with various colours; felspars are susceptible, and others of the silicates: not metallic ores, as a rule. The effect of heating the crystals is not the same in all cases. A. D.

HEAT.

383. *Isothermal and Adiabatic Transformations of Gases; Determination of "γ."* **A. Leduc.** (Comptes Rendus, 125. pp. 1089–1092, 1897.)—1. *Formulæ relating to Perfect Gases.* The author first states the fundamental relations for perfect gases and then replaces these by others, giving exact results for actual gases. For a perfect gas isothermal transformations are expressed, by definition, by the relation

$$Mpv=RT, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

in which M represents the molecular mass of the gas, v the volume occupied by unit mass under the pressure p, at the absolute temp. T.

According to the author's experiments relating to molecular volumes, and adopting for the molecular mass of oxygen the number 32,

$$R=83{\cdot}075\times10^{6} \text{ C.G.S.}$$

Adiabatic transformations take place according to the formula

$$pv^{\gamma}=\text{const.} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Finally the velocity of sound in such a gas is given by the formula

$$V=\sqrt{\frac{p\gamma}{\rho}}=\sqrt{\frac{RT}{M}\gamma}. \quad . \quad . \quad . \quad . \quad (3)$$

The application of these formulæ leads to results more or less approximate. The following are the exact formulæ as stated by the author.

2. *Isothermal Transformations.*—Let ϕ be the ratio formerly defined under the name of *molecular volume* (Comptes Rendus, 125. p. 703),

$$\varphi=\frac{1-y\times10^{-4}}{1+(e-1)z\,.\,10^{-4}+(e-1)^{2}u\,.\,10^{-4}}. \quad . \quad . \quad (4)$$

It follows immediately from the definition of ϕ that, for a real gas,

$$Mpv=RT\phi. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Hence the coefficient of isothermal elasticity,

$$E_i=-v\left(\frac{\partial p}{\partial v}\right)_i=\frac{p}{t-\frac{p}{\phi}\cdot\frac{\partial\phi}{\partial p}}=\frac{p}{1+\frac{p}{\Delta}\cdot\frac{\partial\Delta}{\partial p}},$$

Δ representing the denominator of ϕ.

Frequently $\frac{1}{\Delta}\cdot\frac{\partial\Delta}{\partial p}$ may be replaced by its first term, designated by A. Thus

$$E=\frac{p}{1+Ap}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (6\,bis)$$

3. *Adiabatic Transformations.*—Designating by $\left(\frac{\partial p}{\partial v}\right)_a$ the partial derived in the case of an adiabatic transformation, we have

$$\left(\frac{\partial p}{\partial v}\right)_a=\gamma\left(\frac{\partial p}{\partial v}\right)_i \quad \text{- - - - - - - - (7)}$$

From this follows immediately the coefficient of adiabatic elasticity,

$$E_a=\frac{\gamma p}{1+\frac{p}{\Delta}\cdot\frac{\partial\Delta}{\partial p}}, \quad \text{- - - - - - - - (8)}$$

the denominator reducing to $(1+Ap)$.

Equation (7) may be written

$$\frac{1}{\Delta}\cdot\frac{\partial\Delta}{\partial p}dp+\frac{dp}{p}+\gamma\frac{dv}{v}=0. \quad \text{- - - - - - - (9)}$$

The relation which for real gases replaces the equation of Laplace is

$$\Delta p v^{\gamma}=\text{const.} \quad \text{- - - - - - - - (10)}$$

4. *Velocity of Sound.*—It is sufficient, in order to obtain the velocity of sound at T° *under the pressure* p in a gas of molecular mass M, to replace, in the well-known formula, E and ρ by their values given above.

$$V=\sqrt{\frac{RT\phi}{M}\frac{\gamma}{1+\frac{p}{\Delta}\frac{\partial\Delta}{\partial p}}}$$

$$=\sqrt{\frac{RT}{M}\gamma\frac{10^{-4}-y}{10^{-4}+(2e-1)z+(3e-1)(e-1)u^{2}}} \quad \text{- - - (11)}$$

It should be noticed that γ diminishes when the pressure p increases. Also e is proportional to p. It results that, contrary to the received opinion, *the velocity of sound diminishes when the pressure increases.*

5. *Determination of γ.*—According to Laplace the velocity of sound is probably the most precise means of obtaining γ. The author is led to believe, by the consideration of the numbers calculated from his formulæ, that, in fact, the determination of V in a well-dried gas, at a *temperature* accurately known and *uniform*, will lead to exact results.

The following table is given showing the determinations of Wüllner on air and carbonic anhydride at 0° and 100°. The values γ calculated by means of formula (11) and γ_1 calculated by Wüllner are given for comparison. The numbers at 20° are got by interpolation:—

	V (m. per sec.).	γ.	γ_1.
Air at 0°	331·9	1·4066	1·40526
„ 20°....	„	1·406	1·40491
„ 100° ..	387·7	1·4029	1·40289
CO_2 at 0°	259·28	1·3274	1·31131
„ 20°....	„	1·320	1·3068
„ 100° ..	300·14	1·2902	1·28212

Application.—These values of γ have been utilised for the calculation of the mechanical equivalent of heat, adopting Regnault's values of C and the data of Joule and Lord Kelvin relative to the internal work. The following are two of the numbers obtained:—

	C.G.S.	Kilogrammetres.
Air at 0°	$4{\cdot}206 \times 10^7$	428·7
CO_2 at 0°	4·219	430·1

	C.G.S.	Kilogrammetres.
instead of	4·19	427

which appears to result from the best experiments on friction.

The author postpones to a later paper the discussion of the results obtained. J. J. S.

---

384. *Molecular Velocity of Liquids.* **G. Guglielmo.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 254–261, 1897.)—A theoretical investigation is given of the velocity of the molecules of liquids and its dependence on pressure and temperature, considered under the following heads:—(i) Variations of the molecular velocity as the result of external pressure; (ii) influence of the form of the liquid surface on the vapour-tension; (iii) influence of pressure on the melting-point; (iv) osmosis. For dilute solutions it appears that the theoretical velocity of the molecules of the liquid is approximately equal to the velocity of the molecules of vapour, and for concentrated solutions the expression which agrees best with observation is the following:—

$$v_1^2 = \frac{3}{2}\frac{D_1 - d_1}{D_1 - d_1} h_1 g,$$

where v_1 is the molecular velocity of one of the components of the mixture, D_1 its density when pure, d_1 the weight of it contained in a unit volume of mixture, and h_1 the height of a column of its vapour, such that its tension at the bottom is that of the pure body and its tension at the top is that of the body in the mixture. G. H. Br.

---

385. *Steam Calorimeter.* **M. T. Fullan.** (Amer. Electn. 9. pp. 230–231, 1897.)—A description is given of a simple and inexpensive "throttling" calorimeter. The principle of the apparatus is as follows:—Some of the heat contained in high-pressure steam is liberated when the pressure is lowered, and that

heat is utilised in evaporating any water the steam may contain, and in raising the temperature of the steam above that due to its pressure. A throttling calorimeter, however, cannot be used if the steam contains much over 2·5 per cent. of moisture, but it is described as very convenient and accurate within its limits of operation. A curve diagram is given for use with the calorimeter, the vertical divisions representing absolute steam pressures, and the horizontal ones degrees of superheat in the calorimeter. The special usefulness of the apparatus is to detect and measure the amount of wet steam which many boilers produce, particularly when forced or overworked. J. J. S.

---

386. *Evaporation from a Circular Basin.* **J. v. Pallich.** (Wien. Akad. Sitzber. 106. pp. 384–410, 1897.)—1. The elliptic curves of equal vapour-tension obtained by Stefan by deductive methods for the space above an evaporating surface are of too small eccentricity to agree with the results of experiment; observation requires this to be about twice as great—in one case the linear (*sic*) eccentricity being 95 mm. instead of 51 mm.

2. The expression

$$v = -\frac{k}{P-p}\frac{dp}{dn},$$

which according to Stefan should give the quantity of vapour diffused in one second across a unit area of section, measured volumetrically, only agrees with experiment if, in calculating the level surfaces, their linear eccentricity is taken nearly double of that obtained by him.

3. The same is the case in calculating the quantity of evaporation V from a circular vessel by the formula

$$V = 4ak \log_e \frac{P-p_0}{P-p_1}.$$

4. The difference between the values obtained from theory and experiment increases as the temperature increases.

5. The equation enunciated by Stefan for calculating the quantity of evaporation from any internal part of an evaporating liquid surface, namely,

$$V_1 = V[1 - \sqrt{(1 - r^2/a^2)}],$$

gives for the inner portions of the surface too small values, even when the total evaporation from the entire vessel agrees with that found by experiment.

6. If the quantity of evaporation at a point distant r from the centre of the liquid surface be calculated from the formula

$$v_1 = \frac{V}{2\pi a\sqrt{(a^2 - r^2)}},$$

the result is too small at points near the centre, and too large at points near the circumference. G. H. Br.

387. *Thermodynamic Potential.* **A. Ponsot.** (Comptes Rendus, 126. pp. 226-228, 1898.)—The author gives expressions for the thermodynamic potential of a solution in contact with its constituents, and for the condition that water should pass from one solution to another. R. A. L.

---

388. *Thermal Conductivity of Ice.* **P. Straneo.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 282-289, 1897, and pp. 299-306, 1897.)—1. The coefficient of thermal conductivity of ice is not altogether invariable, but is generally comprised between the limits 0·30 and 0·31, taking as units the centimetre, gramme, minute, and centigrade degree.

2. In ice that is not completely amorphous the conductivity varies slightly in different directions; the following values being obtained in two observations:—

$$k_1 = 0{\cdot}328, \qquad k_2 = 0{\cdot}301,$$

and

$$k_1 = 0{\cdot}325, \qquad k_2 = 0{\cdot}308.$$

The higher values refer to the vertical, the lower to the horizontal directions referred to the position of the ice when frozen.

G. H. Br.

---

389. *Constant-Volume Air-Thermometer.* **J. R. Erskine Murray.** (Journ. Phys. Chem. 1. pp. 714-717, 1897.)—An illustrated description of an simple apparatus, easily calibrated, with a movable reservoir of mercury and a graduated air-gauge. Its sensitiveness can be adjusted to the work required. S. G. R.

---

390. *Diminution of Clearance in Air-Thermometers.* **G. Guglielmo.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 292-299, 1897.)—In open tube-manometers, as well as in air-thermometers, it is desirable that the tube communicating with the gas should be of capillary section; but by reducing its diameter, the error due to capillarity is greatly increased. To avoid this, the branch of the manometer communicating with the gas terminates at its upper end in a cone of semi-vertical angle about 45° with its axis pointing upwards, the mercury being made to reach a fixed point in the cone, and the pressure of the gas being balanced by varying the height of the liquid in the other branch. Two dispositions of apparatus are described, and the second of these serves the additional purpose of a mercurial air-pump, enabling an excellent vacuum to be made, and the exhausted vessel then filled with the gas whose expansion is to be observed. The vacuum is sufficiently perfect for the production of Röntgen rays. G. H. Br.

SOUND.

391. *Combination Tones.* **C. Barus.** (Amer. Journ. Sci. 5. pp. 88–92, 1898.)—The author uses a pipe of constant pitch and a siren of variable pitch. As the siren's pitch increases from zero to the pitch of the organ-pipe, the difference-tones decrease from the latter to zero. Immediately after unison is passed they begin to ascend. The transition is very apparent, even to the untrained ear. The difference-tones and summation-tones of the various orders may be clearly represented by straight lines on a diagram in which ordinates are the pitches of the standard pipes, and abscissæ the uniformly increasing pitches of the siren in terms of time.

E. E. F.

ELECTRICITY.

392. *Magnetic Field due to a Current parallel to an Iron Cylinder.* **G. F. C. Searle.** (Electn. 40. pp. 453–456 & 510–511, 1898.) —When a current flows in a straight wire, in air, parallel to the plane face of an infinite block of iron of constant permeability μ, it is shown that the magnetic force in both air and iron can be derived from a simple system of images. Thus if i be the original current, the magnetic force in the air is the same as that due to the original current i and a current $i(\mu-1)/(\mu+1)$ flowing along its optical image in the face of the iron. The magnetic force in the iron is the same as that which would exist if the iron extended to infinity in *all* directions and the original current were $2i/(\mu+1)$. It is shown that this magnetic distribution satisfies the conditions of continuity of (1) the normal magnetic induction, (2) the tangential magnetic force, or equivalently the magnetic potential.

By writing $1/\mu$ for μ we have the solution for the case in which the current flows in a wire in a "tunnel" bored in the iron block parallel to its face. Diagrams of the lines of induction, drawn by Maxwell's method, are given for these two cases. The same results are shown to hold for a circuit of *any* form near a plane surface of iron.

When a magnetic force H is applied at right angles to the face of an iron block in the second case, there is a force iH dynes per cm. of the current at right angles to both i and H. This is considered by the aid of the Maxwell stress, and the portions of the force borne by the iron and the wire respectively are calculated.

Finally it is shown that when a current flows in a wire inside or outside a solid circular cylinder, cutting a plane perpendicular to the axis in a point A, there is a simple system of images consisting of currents along the axis and along a line cutting the plane in the point inverse to A with respect to the circular section. The values of these currents do not depend upon the distance of the original current from the axis of the cylinder. AUTHOR.

---

393. *Electrostatic Capacity of Two-wire Cable.* **G. W. Patterson.** (Phys. Rev. 5. pp. 309–313.)—If each wire has a radius R, and if the least thickness of the dielectric between the two wires be d, and if the dielectric capacity of the medium surrounding the wire be K (=1 for air insulation, about 2 for paraffin, and about 2·25 for rubber), then the capacity in microfarads per centimetre length is

$$(1206 \times 10^{-10}\mathrm{K}) \div \log\left(\frac{\sqrt{4\mathrm{R}d+d^2}+d}{\sqrt{4\mathrm{R}d+d^2}-d}\right).$$

A. D.

---

394. *Magnetic Elements on Jan.* 1, 1898. **T. Moureaux.** (Comptes Rendus, 126. pp. 234–236, 1898.)—The following are the magnetic elements for Jan. 1, 1898, at the three French observatories :—

	Parc Saint-Maur.	Perpignan.	Nice.
Declination	14° 56′·0	13° 49′·1	12° 10′·3
Dip	64° 58′·9	60° 3′·1	60° 14′·3
Horizontal force....	0·19660	0·22362	0·22332
Vertical force	0·42125	0·38812	0·39054
Total force	0·46487	0·44793	0·44988

At Parc Saint-Maur the secular variation during 1897 was :—Declination −5′·5, dip −1′·9, horizontal force +0·00034, vertical force +0·00013, total force +0·00027. E. E. F.

---

395. *Electromotive Force.* **J. Trowbridge.** (Amer. Journ. Sci. 5. pp. 57–58, 1898.)—By means of an improved Planté rheostatic machine, giving up to 1,200,000 volts, the relation of E.M.F. to sparking distance in air was investigated. It was found that at high values the E.M.F. necessary for sparking increased only at the same rate as the sparking distance, which is in direct contrast to the behaviour at low values, and is in agreement with Lord Kelvin's conjecture. F. T. T.

---

396. *Spark Discharge.* **G. Jaumann.** (Annal. Phys. Chem. 62. pp. 396–406, 1897.)—The author defends his law of discharges from the attacks made by R. Swyngedauw and by Heydweiller. He quotes in particular an experiment made by himself in 1888, which shows the absence of an influence of the form of electrodes on the path chosen by the discharge. E. E. F.

---

397. *Ultra-Violet Light and Spark Discharge.* **E. Merritt.** (Phys. Rev. 5. pp. 306–309, 1897.)—A lecture experiment is described. In circuit let there be two branches, one containing Geissler tube and spark-gap A, the other containing spark-gap B. Finely adjust B, shortening the gap until the spark runs in B and not in A. Then let ultra-violet light shine on the gap A, and the spark passes through A instead of B, and the Geissler tube shines out. The effect of various screens is also easily shown: quartz and gypsum are fairly transparent; glass is as effective a screen as metal. The effect of illumination seems to be equivalent to shortening the gap by a certain constant amount. A. D.

---

398. *Potential Gradients in Vacuum Tubes.* **W. P. Graham.** (Annal. Phys. Chem. 64. pp. 49–77, 1898.)—The fall of potential along the path of a vacuum discharge was investigated by means of fixed and movable electrodes. The results obtained by the latter are the more interesting and less liable to objection. Two electrodes were mounted close together on a glass rod entering the vacuum-tube through the Torricellian column. The potential gradient was thus determined all along the path of the discharge. In the stratified positive part, the gradient was steeper in the bright strata than in the dark ones. Maxima and minima are also observed in the dark space, except at higher pressures. Next the electrodes, the gradient has a minimum value. E. E. F.

399. *Canal Rays.* **E. Goldstein.** (Annal. Phys. Chem. 64. pp. 38–48, 1898.)—The canal rays form the yellow layer next the kathode, whose study has been somewhat neglected in favour of the dark space. If the vacuum is divided into two parts by means of a perforated kathode acting as a diaphragm, the canal rays may be obtained free from admixture with blue kathode light. These rays travel in straight lines. From each perforation a feebly divergent bundle of rays emerges, surrounded by a slight mist. As exhaustion is pushed further, the canal rays converge more and more towards the axis of the tube. They form in fact the prolongation of the kathode rays backward, and their direction only depends upon the front surface of the kathode. The canal rays produce no luminescence, and are not deflected by a magnet.
E. E. F.

400. *Reflected Kathode Rays.* **Villard.** (Paris Soc. Franç. Phys., Bull. 108. p. 6, 1898.)—In focus tubes, the kathode rays which are not absorbed may be reflected or transmitted, retaining their properties. If there be oscillation set up in the inducing bobbin—which occurs when the tube is hard—the anti-kathode itself becomes a source of kathode rays which tend to obscure the result. A. D.

401. *Coloration by Kathode Rays.* **E. Wiedemann** and **G. C. Schmidt.** (Annal. Phys. Chem. 64. pp. 78–91, 1898.)—The authors support their theory of the coloration of alkaline chlorides by further experiments, undertaken with a view of testing whether such coloration is actually due to the formation of subchlorides. The salt was placed in a tube provided with an external kathode, which could be moved along the tube. The salt was exposed to the rays for several days, and shaken up now and then to expose fresh surfaces. On pouring the salt into water containing a little phenol-phthaleïn, a red coloration was obtained. The formation of free chlorine was proved by means of mercury, which formed mercuric chloride. The amount of the salt decomposed is excessively small, but there is no doubt that the coloration is due to a chemical reduction, and not to a physical change.
E. E. F.

402. *New Alternate-Current Voltmeter.* **H. Ebert** and **M. W. Hoffmann.** (Zeitschr. Instrumentenk. 18. pp. 1–4, 1898.)—A voltmeter is described, based on the same principle as Bjerknes' plate-electrometer (Wied. Ann. 48. p. 594, 1893). Two figures of the apparatus are given. A. D.

403. *Application of Vector Algebra to Alternate Currents.* **W. G. Rhodes.** (Elect. Rev. 42. pp. 22–25, 54–56, 90–92, 1898.)—These are three articles on the solution of certain problems in alternating currents by the use of vector algebra. By this method the determination of the equivalent resistances, reactances, and impedances of branched circuits, whether mutual induction is taken into consideration or not, is reduced to the solution of simple equations and the resolution of a resulting vector into two components at right angles. Perhaps the most interesting feature of the method is the ease with which any step in the process may be represented graphically. It is noticeable that there are essential differences between this method and that used by Steinmetz, who treats resistances, reactances, and impedances themselves as vector quantities, whereas in the paper under consideration the only quantities which enter the equations in an explicit manner are electromotive forces and electric currents. The paper is the outcome of an endeavour to treat in a simple manner problems in alternating currents which, while of great importance, are usually considered too difficult to come within the scope of an elementary treatise on the subject. AUTHOR.

404. *Resistance of Silver Films.* **I. Stone.** (Phys. Rev. 6. pp. 1–16, 1898.)—The paper contains an exhaustive account of some experiments on the resistance of thin films of silver deposited on glass by the "Rochelle Salt Process." The resistance, calculated from the specific resistance of solid silver, is but a small fraction of the resistance of the film. The resistance, however, is not constant, but decreases with time, reaching its lowest value only after an infinite period. When the temperature of the film is kept constant the relation between resistance and time, for a given specimen, can be represented by the equation

$$y=e_1+c_2e^{-kt^n},$$

where y represents the resistance, and t the time after the production of the film. Heat accelerates the rate of decrease of resistance. It is probable that the age of the solution from which the silver is deposited influences the fall of resistance, the rate being smaller the older the solution. The author concludes that in general "the decrease of resistance with time is caused by a gradual settling down of the silver molecules into a more and more compact mass. Heat accelerates this motion, bringing in a few minutes the film into that condition which time accomplishes only after months. Preliminary experiments indicate that electric currents and shocks produce a similar effect upon a film as that produced by heat." A. Gs.

---

405. *Failure of Resistance Coils.* **R. Appleyard.** (Phil. Mag. 45. pp. 157–163, 1898.)—Attention is directed to the serious mechanical weakness of certain alloys, particularly of german-silver and platinoid. Several thousands of specimens, in the form of bobbins of wire, were submitted to India, Brazil, Chile, Peru, Ecuador, Nicaragua, Mexico, and Texas. For comparison and reference others were kept in England. In periods of time varying from a few weeks to three years after this distribution, faulty bobbins were reported from certain localities. It happens that these localities all lie on or near sea-coasts. They are nearly all within the isotherm of high terrestrial mean temperature, 25° C. In all cases of failure, the alloy had become brittle and the wire was broken. Some specimens of wire were rotten from end to end. A short history is given of those that failed. It is shown that failure may occur without electric current, and apart from all ebonite, sulphur, and paraffin-wax. Paraffin-wax is highly absorbent of moisture, and quite useless against climate. The deteriorating effects of heat and moisture are not limited to mixed metals. A large tube made of electrolytic copper, presumably pure, became very seriously "pitted" under the influence of steam. Another tube, of the same electrolytic copper, became similarly "pitted" when used for conveying sea-water. When these were replaced by tubes of ordinary copper, there was no further trouble.

The author suggests that two kinds of brittleness ought to be discriminated—(1) "Primary brittleness," as, for instance, that exhibited by gold when alloyed with lead, with arsenic, or with bismuth. In such cases brittleness is characteristic of the alloy from the moment of solidification. (2) "Secondary brittleness," a subsequent and more gradual phenomenon, as, for instance, that exhibited by certain varieties of german-silver, months or even years after solidification. "Primary brittleness" is an accident of birth; "secondary brittleness" is a disease that develops with age and circumstance. Deteriorated german-silver, or platinoid, when examined under the microscope, is seen to contain crevices and fissures; the section has patches of various colours, corresponding, most probably, to separate masses of "liquated" metal. It is further suggested that by the process of "liquation" homogeneity of structure is lost, consequently the tensile strength of the material varies from point to point of its mass, so also does the electrical conductivity. In passing afterwards through the die of the wire-maker, the weaker constituents give way; thus incipient crevices are formed, and through these capillary channels moisture subsequently intrudes. If such wires are used for electric currents, maximum heating occurs at the weakened sections; this accounts for the failure of german-silver resistance-coils on arc-light and other circuits. The separate masses of dissimilar metals constitute local circuits of very small resistance, and within these circuits internal currents act destructively upon the alloys.

The secret of permanence in electrical alloys is being studied with a view to commerce by the Reichsanstalt in Germany. British cable-manufacturers are already importing thousands of tons annually of sheathing wires from Germany, and it is to be regretted that, for want of a National laboratory, British instrument-makers will soon be obliged to obtain their resistance-wire from that same source. AUTHOR.

---

406. *Gravitational Permeability.* **L. W. Austin** and **Chas. B. Thwing.** (Phys. Rev. 5. pp. 294–300, 1897.)—Experiments are described with a modified Boys' gravitation instrument. With screens of lead, zinc, mercury, water, alcohol, or glycerine occupying one-third of the distance between the attracting masses and the needle, the change produced in the attracting forces is certainly less than 0·2 per cent. of the total attraction. With iron the result is not yet distinct, but any change is certainly less than 1 per cent. A. D.

---

407. *Best Resistance for a Sensitive Galvanometer.* **F. A. Laws.** (Phys. Rev. 5. pp. 300–305, 1897.)—If an existing arrangement of apparatus be taken, we can increase its sensitiveness by replacing the galvanometer by a similar instrument wound with wire of a particular size to a resistance equal to *one-half* that of the remainder of the circuit. This best size of wire—taking w as the resistance per unit volume of the wire, C as the diameter of the covered wire, and B that of the bare wire—is that for which $w^{\frac{1}{2}} . B/C$ is a maximum. A. D.

---

408. *Resistivity of Crystallised Silicium.* **F. Le Roy.** (Comptes Rendus, 126. pp. 244–246, 1898.)—The resistivity varies with the pulverisation, compression, and heating of the material, and is about 1333 times that of electric-lighting carbons; and, like that of carbon, the resistance falls off as the silicium is heated, being about 40 per cent. less at 800° C. A. D.

---

409. *Conductivity of Iron Ores.* **A. Abt.** (Annal. Phys. Chem. 62. pp. 474–481, 1897.)—Some of the resistivities obtained are:—

Nickel Ore (Dobsina)	0·0032
Pyrrhotite	0·0084
Chalcopyrite	1·0176
Magnetite	7 to 4900
Hæmatite	1430
Siderite	7175

E. E. F.

---

410. *Electric Curve-Tracer.* **E. B. Rosa.** (Phys. Rev. 6. pp. 17–42, 1898. Also preliminary account, Elect. World, 30. p. 631, 1897, and Electn. 40. p. 26, 1898.)—The author reviews various methods of tracing alternate-current curves, and upholds the step by step method on the ground that this gives the average curve, which is the most generally useful. In the apparatus described a constant potential-difference is maintained between the ends of a wire spirally wound on an ebonite rod, one metre in length, by means of storage-cells; the alternate current to be delineated is passed through a non-inductive resistance, one terminal of which is connected through a dead-beat galvanometer with the middle point of the spiral wire, while the other terminal is joined through a revolving contact-maker to a sliding contact on the spiral. When the sliding contact is so adjusted that the galvanometer deflection is zero, the potential-difference between the terminals of the non-inductive resistance is the same as that between the slider and the fixed contact on the spiral wire, and is proportional to the distance between these points.

The sliding contact is fixed to one end of a pantagraph which carries a marking-point over a recording cylinder; the excursion of the marking-point is proportional to that of the slider, but is reduced in the ratio 8 : 1. By raising a lever, the circuit of an electro-magnet is closed, causing the marking-point to print a dot on the recording cylinder; the downward motion of the same lever actuates a pawl and ratchet gear, which rotates the cylinder one step, and at the same time advances the brush of the contact-maker through a corresponding angle. The lever is operated with one hand, while the slider is adjusted to give zero deflection with the other. Observations may be made very rapidly, as many as 20 points per minute being obtained without difficulty. In an improved form of the apparatus, the recording cylinder and contact-brush are simultaneously set by means of electro-magnets, so that the recording apparatus may be placed at a distance from the contact-maker and alternate-current generator.

A full description of the mechanical details of the curve-tracer is given; and a number of curves obtained under various conditions by means of the apparatus are shown and discussed. Harmonics having frequencies up to 15 times that of the fundamental are reproduced with great fidelity, and the effects of inductance, resistance, and capacity respectively on the wave form are clearly shown. When resistance predominates, the harmonics of the electromotive-force curve reappear in the current-curve unchanged; when the circuit is highly inductive they are damped out, especially those of a high order; and when the capacity is great the harmonics are intensified. The electromotive-force curve is propagated through a series of transformers without any appreciable change.

A. H. A.

---

411. *Electric Osmosis.* **F. Braun.** (Annal. Phys. Chem. 63. pp. 324–328, 1898.)—Describes the motions of a membrane

dividing two electrolytes traversed by a current, due to the unequal effect of the salts upon the tension of the membrane. These motions are instantaneous on reversal of the current, and shed some light on certain biological phenomena. E. E. F.

---

412. *Thermal Mercury Ammeter.* **C. Camichel.** (Comptes Rendus, 126. pp. 240–242, 1898.)—This is an improvement of the ammeter described last year. It consists of a thread of mercury in a tube which joins two small bulbs containing pure mercury and wire-terminals for insertion in the circuit to be studied. The whole is immersed in the thermometric vessel, and the heat developed in the thread is a measure of the current intensity, the rise of temperature per unit time being proportional to the square of the current. The errors due to cooling and the change of resistivity are rigidly compensated in this instrument. It is particularly suitable for currents between 1 and 2 amperes, and the error is only 0·5 per cent. E. E. F.

---

413. *Measurement of Hysteresis Losses.* **G. L. W. Gill.** (Électricien, 15. pp. 40–41, 1898.)—The apparatus used for the above purpose measures the mechanical work performed on a sample of iron, when it is magnetised through complete cycles. The magnetic field is produced by a solenoid wound on a brass tube. This is so arranged as to be capable of sliding vertically up and down, and can be stopped at any position. The sample under observation is placed in a stirrup of small enough dimensions to pass into the solenoid and is suspended from a spiral spring, the point of suspension being above and in the axis of the solenoid. Another spiral spring fixed under the stirrup keeps it in line. The apparatus is so arranged that when the solenoid is in its lowest position, the iron is out of the magnetic field. By raising the solenoid the iron passes through the solenoid and is once more out of the field, when the solenoid has reached its highest position. By this means the iron can be magnetised through complete cycles. The work performed in the up and down strokes can be determined by measuring the attractive force for different positions of the solenoid, and drawing a diagram of forces in function of the positions. The integral of this curve gives the work performed. The forces at different positions can be measured by calibrating the springs which support the stirrup. The author was able by this means to determine the losses by hysteresis in different samples of iron and at different inductions, by observing the elongation of the springs by means of a microscope. In order that this apparatus should be complete, it has been fitted with an integrating apparatus which gives a direct reading of the work performed. The moving parts of the integrator consist of a steel wheel working on a glass disc. The apparatus is calibrated by placing a known weight in the stirrup, and observing the reading on the integrator during a given travel of the solenoid. L. J. S.

414. *Magnetisation of Clay during Firing.* **G. Folgheraiter.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 368–376, 1897.)—In endeavouring to rediscover the method used in colouring the celebrated black Etruscan pottery, the author notes that all the specimens he examines are markedly and permanently magnetised. Unbaked ferruginous clay, such as is used in the manufacture of common red pottery, is neither magnetic nor susceptible of magnetisation by a powerful field; but at the temperature at which it begins to lose its plasticity and to cease to be disintegrated by water, signs of magnetisation appear, provided the mass is kept in one position in the earth's field during heating; and at a dull red heat, at which temperature the calcium carbonate of the clay is dissociated, the magnetisation is very marked. The Etruscan ware loses the carbon to which its colour is due far below this temperature, and probably consists therefore of red pottery, which after firing is soaked in bituminous liquid and heated to a moderate temperature whilst surrounded with charcoal. J. W.

415. *Magnetic Detection of Iron.* **W. Duane.** (Annal. Phys. Chem. 62. pp. 543–544, 1897.)—The presence of iron in a body may be demonstrated by the damping undergone by the body when vibrating in a magnetic field. But a more sensitive method consists in suspending the body in a rotating magnetic field. The deflection shown is due to the coercive force, and not to eddy currents, as shown by the fact that it is independent of the angular velocity of the field. The new method is more sensitive than the most delicate chemical reaction for iron. E. E. F.

416. *New Method of measuring Magnetic Fields.* **E. Bouty.** (Comptes Rendus, 126. pp. 238–240, 1898.)—The method is based upon the mutual induction employed by M. Lippmann in his mercury galvanometer. A conducting liquid, which may be simple tap-water, flows normally to the lines of force of the field to be measured. By means of the capillary electrometer the constant induced E.M.F. between the upper and lower end of the jet is measured. Knowing the amount of flow, the field intensity may be found. The induced E.M.F. is $E = Hvl$, where H is the field, v the velocity of flow, and l the breadth of the jet. The outflow is $D = vel$, where e is the thickness of the jet. This gives for the field

$$H = \frac{Ee}{D}.$$

The velocity may be varied from 0·5 to 17 m. per second, and fields down to 0·5 C.G.S. units may be measured. E. E. F.

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

417. *The Hulin Electrolytic Alkali Process.* **J. B. C. Kershaw.** (Electn. 40. pp. 623–625, 1898.)—The author describes the early difficulties met with by Vautin in his attempts to electrolyse fused salt upon a commercial scale with a molten lead kathode. A modification of this original process has been patented by Hulin, who discovered that the difficulties could be overcome by electrolysing a mixture of fused lead and sodium chloride. The lead, electrolytically separated at the kathode, serves to combine with the sodium as it forms, and the molecules of the lead-sodium alloy diffuse into the molten lead without hindrance. This process has been tried upon an industrial scale at the paper-works of MM. Matussière et Forest, Modâne. The crucibles containing the fused mixture of the chlorides were worked in series in sets of four. Each crucible contained a lead and a carbon anode, and 12 °/₀ of the current was caused to pass into the electrolyte by the former, in order to maintain the required proportion of lead chloride in the mixture. An E.M.F. of 7 volts per crucible, and a current-density of 700 amperes were used. The author gives tables showing the current and energy efficiencies of the Hulin process, as compared with those of the wet electrolytic alkali processes now at work in this country. A table is also given showing the comparative expenditure upon power by the Hargreaves, Castner-Kellner, and Hulin processes. The higher figure in the case of the latter is expected to be balanced by the economies and gains resulting from the high productive capacity per unit of plant, the high concentration of the alkaline solution produced, and the value of the by-products—spongy lead and lead peroxide. The author states finally that the experimental plant at Modâne is now stopped, and that a Company has been formed, with a capital of £120,000, to carry on the manufacture of alkalies and chlorine products by the Hulin process at Clavaux. A water-power of 5000 H.P. is available at this spot; the works are already more than half completed, and the manufacturing operations are expected to be commenced before the end of the present year.

AUTHOR.

418. *Electrolytic Separation of Copper from Silver, Mercury, and Arsenic.* **N. Revay.** (Zeitschr. Elektrochem. 4. pp. 313–316, 1898; pp. 329–333, 1898.)—In the first instalment of the paper the separation of silver from copper is dealt with. The difference of potential between these two metals with regard to solutions of their respective salts being about 0·45 volt, there should be no difficulty in separating them by electrolysis, and as a matter of fact, with Classen's apparatus, the kathodal platinum basin being burnished to secure adhesion of the silver, a quantitative deposition of the metal in presence of copper can be effected both in acid and

in cyanide solution. The E.M.F. calculated for the decomposition of silver nitrate is 0·9 volt, whilst 1·34 volt should be required for copper nitrate; and it is found experimentally that a current of 0·2–0·25 ampere at 1·3 volts, over a period of from 5 to 14 hours, completely precipitates the silver from solutions containing from 0·25 to 0·3 gram of silver nitrate and an equal amount of copper sulphate. The adhesion of the deposited silver is facilitated by keeping the electrolyte at about 70°, and excess of acid should be present to prevent the deposition of silver peroxide on the anode. The specimen results quoted are good, the maximum deviation from the mean being 1 in 1000. The addition of excess of potassium cyanide to the electrolyte proves in practice to diminish the reliability of the process; for, although the silver deposit is denser and more coherent, and there is no risk of forming peroxide, the E.M.F. required varies with the concentration of the silver and with the relative amount of copper present. Approximately quantitative precipitation of the silver is obtained only in presence of comparatively small amounts of copper, and if the latter is largely in excess it may happen that it is precipitated first.

In the second instalment of the paper the separation of copper from mercury and arsenic is considered. The potential difference between copper and mercury with regard to corresponding solutions being about 0·4 volt, there should be no difficulty in separating the two metals electrolytically; but in acid solution very unsatisfactory results are obtained, in part owing to the formation of insoluble basic mercurous salts, and in part owing to the precipitation of the mercury in pulverulent form. Sometimes, moreover, owing to the low resistance of the acid solution, the E.M.F., even with a current of 5 amperes, falls below that required for the deposition of mercury. In cyanide solution fairly good results are obtained, provided the relative amount of copper does not exceed about 25 per cent.; the last traces of mercury, however, cannot be precipitated, as when the concentration of the mercury ions falls below 1/384th of the normal, the E.M.F. of decomposition, which is a function of the concentration, becomes greater than that of the potassium cyanide, and hydrogen is liberated at the kathode instead of mercury.

Copper can be separated from arsenic effectively only when the latter is present in pentavalent and negative form, *i. e.* as a salt of arsenic acid, trivalent arsenic being deposited with the copper on the kathode. Good results are obtained with a solution of copper sulphate and potassium arsenate strongly acidified with sulphuric acid, the E.M.F. ranging from 1·6 to 1·8 volts, and the current from 0·01 to 0·04 ampere; the precipitated copper is entirely free from arsenic, except when the E.M.F. exceeds the above limit, in this case the arsenic being reduced. Reduction takes place most readily in hydrochloric-acid solution, and least readily in a sulphuric-acid solution. In ammoniacal solution the results are not quite so good. J. W.

419. *Electrolytic Separation of Copper from Nickel, Iron, and Zinc on a Manufacturing Scale.* **B. Neumann.** (Zeitschr. Elektrochem. 4. pp. 316–322, 333–338, 1898.)—When crude copper is made the anode in an acid bath of copper sulphate, the less positive of the foreign metals present—silver, gold, platinum, bismuth, tin, arsenic, antimony, lead,—pass sooner or later into the anode slime, but the more positive metals—nickel, cobalt, iron, and zinc—remain in solution, and thus gradually reduce the concentration of the copper salt. Moreover, a greater weight of these metals is dissolved than is equivalent to the copper deposited on the kathode, and the electrolyte therefore becomes steadily richer in metal and poorer in acid; iron in particular is dissolved in the ferrous state at low current-densities, but in the ferric state when the density exceeds 0·13 ampere/sq. cm. The question which the author investigates is: Up to what concentration of foreign metals is it profitable to continue the electrolytic deposition of the copper? Alloys of copper and cobalt are only of theoretical interest, on account of the high price of the latter, and those of copper and iron are not worth attention, on account of the sparing intersolubility of the two metals; but the separation of copper from german-silver and scrap-brass, and in particular from the copper-nickel alloy obtained by ordinary metallurgical processes from the Canadian nickel ore, is of technical importance.

Plates of the alloys in question are made the anodes against kathodes of sheet copper in a series of five cells, and the electrolyte, consisting of copper sulphate, strongly acidified with sulphuric acid and warmed to an appropriate temperature, is kept in steady circulation through the series. With copper-nickel anodes (containing 50 °/₀ of each; also 0·63 °/₀ of iron) at 30°, with an E.M.F. of 0·3–0·4 volt per cell, the current-density in the course of 32 hours gradually falls from 0·022 to 0·008 ampere/sq. cm.; the percentage of copper in the electrolyte gradually falls from 0·046 to 0·006 gram per c.c., whilst that of nickel steadily rises from zero to 0·044 gram/c.c.; iron appears in weighable quantity only after the 28th hour. The copper is at first deposited in bright, regular, dense condition, but about the 24th hour it becomes darker in colour, and less regular in surface, and after the 27th hour the deposit is so spongy that it can be rubbed off. At the end of the 32nd hour, the resistance of the cells is so great that it is not worth continuing the experiment. Substitution of pure nickel anodes for those of the alloy at this stage permit of the reduction of the copper concentration to 0·0002 gram per c.c., but the metal is deposited in a still less coherent form, and the amount of nickel dissolved is excessive, for, owing to the sparseness of the copper ions, a large portion of the current is carried by hydrogen ions, and hydrogen is liberated at the kathode. It is thus impracticable on a manufacturing scale to eliminate all the copper from the electrolyte in copper-nickel separation, either with copper-nickel or with pure nickel anodes. The author suggests precipitating this residual copper with sulphuretted hydrogen, obtained practically free of cost by the action of sulphuric acid on the unroasted copper-nickel sulphide: the resulting solution of copper and nickel sulphates can then be treated electrolytically as above until the copper reaches the limiting concentration. As to the separation of the iron from the nickel sulphate solution, the method of blowing air through the hot solution is useless for manufacturing purposes, as even after 19 hours 25 per cent. of the iron remains in solution.

The results obtained with anodes of brass and copper pyrites are similar, in each case there occurring a point beyond which it is no longer profitable to precipitate the copper electrolytically. In all cases the electrolyte must be fairly rich in copper, and the processes described by various authors, in which the electrolyte consists of sulphuric acid alone, are technically worthless on account of the lack of coherence of the deposit. J. W.

---

420. *Electrolysis of Platinum Chloride.* **F. Kohlrausch.** (Annal. Phys. Chem. 63. pp. 423–430, 1897.)—Two forms of the chloride were electrolysed, viz., H_2PtCl_6 and $PtCl_4 . 5H_2O$. For the former, the current was kept so feeble that no gas was given off at the kathode. The amount of platinum deposited increased with the current, but not in proportion to it. The valency of the platinum appears to be between 2 and 3, and not 8 as has been supposed. The anode remained unaffected. In the case of $PtCl_4 . 5H_2O$, the extraordinary result was obtained that at low current-densities below 0·02 ampere per $cm.^2$ no platinum at all was deposited. Hydrogen is given off instead, and, at greater current-densities, has the effect of reducing platinum from the chloride. But this is a secondary action. At the anode, oxygen is given off. E. E. F.

---

421. *Alternate Current Electrolysis.* **R. Malagoli.** (Écl. Électr. 13. pp. 255–260, 1897.)—The author has carried out experiments, chiefly with gaseous products of electrolysis, to determine how far Faraday's laws are modified in the case of alternate currents. The following conclusions are deduced:—(1) For a given electrolyte, even of different strengths, the decomposition is the same for a number of voltameters in series provided the electrode surface is of the same area in each. (2) The amount of decomposition is proportional to the duration of electrolysis. (3) The amount of decomposition is proportional to the number of coulombs that have passed, provided the current-density is constant. (4) The amount of decomposition depends upon the electrochemical equivalents of the ions in question, and upon the difference between the coulombs passing during each half-period and double the quantity of electricity necessary to completely polarise the electrodes. These results are in accordance with the formula

$$d = tne(Q - 2sq_0),$$

in which d is the amount of decomposition, t the duration of electrolysis, n the frequency, e the electrochemical equivalent of the ion under consideration, Q the quantity of electricity flowing during each half-period, s the surface of each electrode, and q_0 the quantity of electricity necessary to completely polarise unit surface of the electrodes. W. R. C.

422. *Electrolytic Behaviour of Fluorine Compounds.* **A. Miolati** and **U. Alvisi.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 376–381, 1897.)—According to Werner's extension of the stereometric theory of chemical constitution, the valencies of a hexavalent atom proceed from the angles of a regular octahedron, so that it is physically impossible for such an atom to combine with more than six others. The authors show, however, that the diminution of conductivity of an aqueous solution of potassium fluoruranate, $K_3UO_2F_5$, on dilution is consistent only with the assumption that the salt is dissociated into the ions K_3 and UO_2F_5, the latter negative ion thus forming a trivalent complex in which the hexavalent uranium atom is united with seven other atoms. A number of similar salts are examined, but they are all dissociated hydrolytically by water, and thus afford no light upon the question. J. W.

423. *Mass Law.* **B. Kuriloff.** (Zeitschr. Phys. Chem. 24. pp. 697–702, 1897.)—The author gives examples of its relation to β-naphthol and picric acid in benzene solution. The picrate undergoes by rise of temperature an easy dissociation proportional to the amounts of the two substances present; the dissociation being indicated by the change in solubilities of the base and acid. S. G. R.

424. *Chemical and Physical Equilibrium studied by Osmotic Pressure.* **A. Ponsot.** (Comptes Rendus, 126. pp. 335–338, 1898.)—A mixture of substances forming a homogeneous or heterogeneous system in equilibrium being given, the author proposes to find the substances really existing in the mixture, to submit it to variations of temperature, pressure, and composition, and find the relations existing between these variations, and to establish the conditions of equilibrium by means of semipermeable membranes only permitting the passage of one of the substances. The differential equations connecting reversible pressure, temperature, and concentration changes in the system under these circumstances are briefly deduced from the two laws of thermodynamics; and it is pointed out that these, together with the gas laws and van't Hoff's osmotic pressure laws, give the solution of the problem proposed. No experimental applications are mentioned. T. E.

425. *Composition and Density of Air.* **A. Leduc.** (Comptes Rendus, 126. pp. 413–416, 1898.)—The author compares his results with those of other experimenters, particularly those of Lewy, and discusses the causes of the discrepancies between them. He attributes these to sources of error in the different methods employed. The amount of oxygen present in the air he finds to

vary with the season, the altitude, the proximity of the sea, and also perhaps with the latitude.

In this last connection a comparison of Rayleigh's results with the author's is interesting. The densities of all the gases determined by the two experimenters agree, if the density of oxygen is taken as the standard in each case; but if air be taken as the standard, then all the densities as compared with London air are greater than those compared with Paris air: the inference being that London air is less dense than Paris air—that is, it contains less oxygen. J. B. H.

426. *Ozone.* **M. Otto.** (Annal. Chim. Phys. 13. pp. 77–144, 1898.)—Otto's researches have already been referred to in Phys. Soc. Abstracts, 1897, Nos. 219, 638, 683. The present paper covers the same ground. It refers to the relation between tension, necessary for producing ozone, and the distance between the glass plates in the arrangements—metal, glass, air, glass, metal; or metal, glass, air, metal, glass: it describes the transformers and ozone-generators: and establishes the law that the yield grows proportionally with the number of periods. With a current at 80 periods and 6500 volts, he obtained 3·718 kg. of ozone in 24 hours, which would correspond to an efficiency of 15 per cent. The air-current through the apparatus should be rapid.

The second, longer part of the paper deals with the action of ozone on methane; on some benzene derivatives with open side-chains, as eugenol, safrol, estragol; monatomic alcohols, glycol and glycerine; phenol, resorcin, hydroquinone, etc.; phenylamine and paratoluidine. The much disputed ozone-determinations are not mentioned on this occasion. H. B.

427. *The Electric Furnace.* **Gin** and **Leleux.** (Comptes Rendus, 126. pp. 236–238, 1898.)—If the heating of the arc by the current were adiabatic, the temperature would be proportional to the square of the current-density and to the resistivity of the medium, and inversely proportional to its volume specific heat. Adiabatic heating cannot of course be realised, but it can be approximated to by letting the arc play in a medium consisting of the powdered mixture used for the manufacture of calcium carbide. The arc then forms a chamber with a crater at the top, through which the hot gases escape. After cooling, the walls of the cavity are concentrically stratified in successive layers, consisting of shining graphite inside and crystallised calcium carbide outside that, surrounded by the unaltered powder. This shows, in the first place, that the temperature of the arc itself is too high to allow the calcium carbide to remain combined. If calcium carbide is thrown into the crater it is vaporised and dissociated, as shown by the fact that the escaping gas does not form acetylene. E. E. F.

428. *Precipitation of Salts.* **A. E. Taylor.** (Journ. Phys. Chem. 1. pp. 718–733, 1897.)—It has been found that in the precipitation of salts from aqueous solutions by alcohol or acetone, the results could be expressed by an equation of the general form

$$(x+\mathrm{A})y = \mathrm{C},$$

where x and y represent respectively the weight of alcohol and of salt in a fixed weight of water. The present paper gives a number of experiments with potassium chlorate and bromide, sodium chloride and nitrate, undertaken with the view of testing the formula.

The conclusion arrived at is that ternary mixtures of this type behave in accordance with the general equations

$$(x+\mathrm{A})y^n = \mathrm{C} \quad \text{and} \quad (x+\mathrm{A})(y+\mathrm{B})^n = \mathrm{C},$$

n being independent of temperature but varying with the precipitant, while A and B vary with temperature and are each characteristic of one of the non-miscible substances, A being a function of y and B of x. S. G. R.

---

429. *Transition-Point of a Solid Solution.* **V. Rothmund.** (Zeitschr. Phys. Chem. 24. pp. 705–720, 1897.)—The change in the transition-temperature of a solid substance, capable of existing in two modifications, which is produced by dissolving in it an isomorphous substance so as to form a solid solution, is analogous to the change of freezing-point of a liquid under similar conditions. Assuming that in these solid solutions the relative depression of the vapour-pressure is equal to the molecular concentration of the dissolved substance, so long as this is small, the author obtains the equation

$$t_0 - t_1 = \frac{\mathrm{RT}^2}{\mathrm{Q}}(c_2 - c_1),$$

in which t_0 and t_1 are the transition-temperatures of the pure substance and of the dilute solid solution respectively, Q the heat absorbed by the conversion of the first into the second modification, and c_1 and c_2 the concentrations of the dissolved substance in the two modifications at t_1. According to Nernst's law of partition,

$$\frac{c_1}{c_2{}^n} = k,$$

where k is independent of the concentration and n indicates how many times greater the molecular weight of the dissolved substance is in the second phase than in the first. If $n=1$, we have

$$t_0 - t_1 = (\mathrm{RT}^2/\mathrm{Q})(1-k)c_2;$$

that is, the change of transition-temperature is proportional to the concentration of the dissolved substance when the molecular weight of the latter is the same in both solid solutions.

The author has experimentally investigated solutions of carbon tetrachloride in carbon tetrabromide. The latter forms crystals belonging to the regular system above 46°, which change into monoclinic crystals at lower temperatures. The transition-temperature was determined by the dilatometer and thermometer as 46°·91 for the pure substance; this was depressed by addition of carbon tetrachloride in proportion to the amount added. The depression produced by the addition of one molecule of the chloride to 100 molecules of the bromide varies irregularly from 0°·92 to 1°·16 in different concentrations. T. E.

GENERAL ELECTRICAL ENGINEERING.

430. *The "Allan" Accumulator.* (Elect. Rev. 42. pp. 211–212, 1898.)—In the Allan accumulator, which has been on the market about three years, the paste in both positive and negative elements is supported in a hollow frame having lattices extending from edge to edge on both sides, the paste being forced into perforations in these edges. As the active material is thus in one unbroken mass, and is supported wholly from the outside, the plates are quite free from any tendency to buckle. The rate of discharge for three hours is said to be 1·5 amperes per pound weight of cell, the average energy-capacity at this rate is 9·0 watt-hours per pound, and the total current-capacity 6 ampere-hours per pound. The weight is about 32 pounds per cell, and 40 cells measure outside 35 × 24 × 12 inches high. The accumulator is thus very suitable for traction. J. W.

431. *Light Accumulator.* **F. Pescetto.** (Ind. Élect. 6. pp. 472–473, 1897.)—The author points out that a high current-density in charging gives rise to evolution of gases, and therefore, in order to render high current-density possible, the gases should have a more easy access to the interior of the active matter or be absorbed by it. Similarly, for high discharge-rate, the acid should have free access. Experiments were carried out with Cruto plates. It was found that by adding to the paste *ulmate d'ulmine* (obtained by suitably treating sugar with sulphuric acid), these objects are to some extent attained. The following results are given, and refer to weight of plate :—

Charge (amperes per kilo).	Discharge (amperes per kilo).	Energy (watt-hours per kilo).
2	4·6	26
2	8·5	24
10	4·6	13
10	8·5	12
20	4·6	7
20	8·5	6·8

W. R. C.

432. *Ship-wiring.* **E. W. Countiss.** (Amer. Electn. 10. pp. 77–78, 1898.)—The author gives a number of details of American practice in wiring ships for the electric light. The paper is not suitable for abstracting. A. H. A.

433. *Enclosed Fuse.* **D. J. Cartwright.** (Amer. Electn. 10. pp. 61–62, 1898.)—In this type of fuse the fusible wire is enclosed in a tube of fibre which is tightly closed and provided with slotted lugs at the ends ; these lugs are adapted to be secured to terminals

on the base of the fuse, and are connected to opposite ends of the fuse-wire. Inside the tube, the fuse-wire passes through holes in partitions dividing the internal space into three chambers so as to leave a definite air-space surrounding the wire in the chambers. In this device, when the fuse melts within the central chamber, the heated air and gases formed, in forcing themselves into the outer or end chambers, blow out the arc. A 50-ampere fuse would melt in less than three minutes on a current increase of 25 per cent., and will open a 500-volt circuit of 450-k.w. capacity without noise or flash when short-circuited thereon. A similar fuse has been short-circuited on a 2200-volt alternator within 10 feet of the dynamo without any extra resistance or shunt in the circuit, and opened the circuit without maintaining an arc between the terminals, which were 6½ inches apart. These fuses can be operated in rooms filled with inflammable gas.

C. K. F.

---

434. *Electrical Measuring-Instruments.* **H. Armagnat.** (Écl. Électr. 14. pp. 58–66, 1898.)—This paper contains illustrated descriptions of recording electrical measuring-instruments, both for direct and alternating current. The latter portion is devoted to automatic electricity meters—penny-in-the-slot meters,—those described being the Willy and Simpson, the Burchard, the Cousens, and the Dixon automatic meters. W. G. R.

---

435. *Phase-splitting Device.* (Elect. Runds. 15. pp. 77–79, 1898.)—**Siemens** and **Halske** have recently patented a method of producing a current from monophase alternating mains which can be made to have any desired phase-relation to the P.D. between the mains. The method consists in connecting across the mains $M_1 M_2$ (fig. 1) a Wheatstone's bridge network A B C D, the required current being tapped off between the points B and D. One pair of opposite arms of the bridge consists of inductance-coils; the other of non-inductive resistances. Fig. 2, which is lettered

Fig. 1.

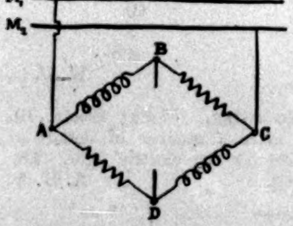
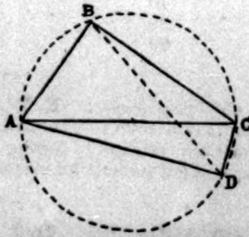


Fig. 2.



so as to correspond with fig. 1, gives the magnitudes and phase-relations of the various P.D.'s in the network (the resistance of the inductance-coils being neglected). It is obvious that by suitably adjusting the values of the resistances and inductances, the line BD (fig. 2) may be made to make any angle with AC. Two examples of the practical application of this method are given. One is in the construction of watt-meters or energy-meters whose moving parts, consisting of a copper cylinder surrounding a laminated iron core, forms the armature of a Ferraris motor, the rotating field being produced by two sets of coils, one of which is placed in the main circuit, while the other is connected across the points B and D (fig. 1) of the Wheatstone's network. If the currents through the two sets of coils be $I_1 \sin pt$ and $I_2 \sin (pt - a)$, then the couple acting on the rotor is proportional to $I_1 I_2 \sin a$. Now if the adjustment be made so that the current in the shunt-coils is exactly 90° in phase behind E, the P.D. of the mains, then it follows that the couple will be proportional to $EI_1 \cos \theta$ (where θ is the angle of lag of the main current behind the P.D.)—*i. e.* to the power. If the couple be balanced by the torsion of a spiral spring, the instrument becomes a watt-meter; but if the copper cylinder is, with suitable damping arrangements, allowed to rotate, we get an integrating watt-meter. The second application of the principle is to the starting of single-phase induction motors. These are provided with a supplementary winding, which at starting is connected between B and D (fig. 1). Experiment shows that an exceptionally powerful starting-torque may be obtained by this method. As soon as the motor gains speed, the supplementary winding is disconnected from the mains. A. H.

---

436. *Electrically Lighted Buoy.* (Elect. World, 31. p. 274, 1898.)—A description is given of a buoy invented by **D. M. Fletcher**, which is automatically lighted by wave-power. The buoy consists of a hollow steel shell 6 feet in diameter, which works upon the end of a plunger fixed to the anchorage. The plunger actuates a double-acting pump, which delivers water under pressure to a Pelton wheel coupled to a small dynamo; the latter supplies current to a 50-candle power incandescent lamp in a lantern on the top of the buoy. Means are provided to ensure continuity of lighting. A. H. A.

---

437. *Aluminium and Copper.* **A. E. Hunt.** (Elect. Rev. N. Y. 32. p. 118, 1898.)—The writer, who is President of the Pittsburgh Reduction Company, compares the advantages of aluminium with those of copper and brass for electrical conductors. In America copper is about 14 cents a pound, aluminium is 29 cents, giving a cost ratio of 0·48. The density ratio of copper to aluminium is 3·332. Taking the electrical conductivity of copper at 100, aluminium has a conductivity of 63; this refers to the variety specially manufactured for electrical purposes. On this

basis the sectional area of an aluminium conductor of given resistance and length requires to be about 1·6 times that of an equivalent copper conductor. But since the density ratio is 3·332, the aluminium conductor has a weight only 0·48 that of the copper of same length and resistance. As regards the cost of equivalent conductors, there is consequently little to choose. The writer, so far, only discusses bare wires; he does not consider the additional cost of insulation for the increased section for covered conductors. Tensile strength for a given sectional area is the same both for aluminium and copper; the equivalent electrical conductor of aluminium is thus 1·6 times stronger than copper of equal electrical resistance. It is assumed that for aerial lines the snow-and-ice load is practically independent of the gauge; the advantage here is on the side of copper. As aluminium has less weight and greater strength than the equivalent copper conductor, aerial lines of aluminium can be allowed proportionately longer spans, with a corresponding diminution in the number of poles and insulators.

If aluminium is drawn too severely through the dies, or if it is not well-annealed at the proper intervals in the drawing operations, it is finished much more brittle than is represented by the above figures. Alloying has been adopted with some success as regards increase in tensile strength, but there appears to be a corresponding falling-off in the conductivity. Thus a certain alloy has a tensile strength of 65,000 pounds per sq. inch, with a conductivity of 50 per cent. on Matthiessen's standard. Aluminium is said to resist corrosion much better than does copper. R. A.

---

438. *Lightning Protector.* **Siemens & Halske.** (Électricien, 15. pp. 152–153, 1898.)—This guard, made by Siemens and Halske, consists of two pieces of stout copper wire bent in the form of horns and supported on insulators so that they are in the same plane and are near together at the bottom and diverge upwards. One of the horns is connected to the line wire, and the other to earth. When the line is struck by lightning, the arc forms at the bottom and rises, by reason of the heating of the air and the magnetic field produced by the current flowing to earth, until it reaches a definite height, when it breaks automatically. C. K. F.

DYNAMOS, MOTORS, AND TRANSFORMERS.

439. *Walker Alternator*. (Elect. Engin. 21. pp. 83–84, 1898.) —An illustrated description is given of the new type of inductor alternator built by the Walker Company, U.S.A. The revolving inductor has, besides the usual exciting coil, a coil which is supplied by the rectified current from a portion of the armature circuit, the alternator being thereby compounded for incandescent lighting.
A. H.

440. *Testing Dynamos*. (Amer. Electn. 10. pp. 80–81, 1898.) —Two methods are described, specially applicable to small machines whose friction losses would be less than those in any of the usual extraneous testing devices.

(1) With small machines up to ½ H.P., mount the armature between lathe-centres, so that it can be driven as a generator; counterbalance the field-magnets, so that they will remain in any position relatively to the armature, taking care that any metal attached for this purpose does not affect the magnetic circuit; bolt to the magnets a lever-arm, carrying a pointer moving over a scale against the pull of a spring-balance, and damped by a water dash-pot. Adjust the tension on the spring-balance till the pointer is at zero when the armature is (1) at rest, (2) revolving so as to generate full load. Then, if L is the length of the lever-arm in feet [and P is the difference in the readings of the balance when the armature is stationary and when] revolving at N revs. per min., the work put in is $2\pi LN[P]$ [by an obvious slip the author forgets to bring any 'P' into his results], while the output can be deduced from the volts and amperes generated.

(2) A calorimetric method: the dynamo is placed inside a felt-covered box through which air is pumped, the quantity being measured by an anemometer and the temperature noted at inlet and outlet. Knowing the specific heat of air, the losses in the dynamo can at once be obtained in thermal units, which, when divided by the constant, are converted into H.P. The method is inaccurate and very troublesome. E. H. C.-H.

441. *Four-pole Dynamo*. (Elect. Rev. N. Y. 32. p. 47, 1898.) —The General Electric Co. describe a new line of four-pole dynamos. The frame is of cast iron, with soft steel pole-pieces, which are detachable, so that the field-coils can be removed without disturbing the armature. The armature is built up of japanned sheet-iron laminations, mounted on a cast-iron spider. The windings are copper coils formed and insulated before assembling on the core. The temperature rise, after a full-load run of 10 hours, will not exceed 55° C. for the commutator, or 45° C. for any other part of the machine. R. B. R.

442. *Armature Connection.* **A. L. Rice.** (Amer. Electn. 10. pp. 56–58, 1898.)—The author describes, with diagrams, a two-pole gramme winding and two varieties of two-pole drum winding, lap winding, and wave winding. Taking in each case a drum armature with 24 bars, numbered consecutively, in lap winding the connections are 1 to 12 at back, 12 to 3 at front, 3 to 14 back, etc., giving a back pitch of 11 and a front pitch of 9: in wave winding the connections are 1, 12, 23, 10, 21, etc., giving a front and back pitch of 11. The paper is illustrated by clear diagrams.

R. B. R.

---

443. *Rushmore Multi-voltage System.* (Elect. Rev. N. Y. 32. pp. 76–77, 1898.)—S. W. Rushmore found that, by properly distributing the current in the armature and controlling the excitation of the different poles, an ordinary multipolar generator can be made to deliver its output at as many different and independently variable voltages as there are pairs of field-poles, so that each pair of poles constitute, as it were, a separate generator with the voltage from each pair of brushes independently variable from zero to a maximum without the least mutual interference. This being the case, one pair of brushes may lead to a lighting circuit and another pair to a motor circuit without the lights being in the least affected by the stopping or starting of the motors, and the speeds of the motors may be varied at pleasure by simply varying the electromotive force supplied to them by the dynamo.

In connection with accumulators, the machine may run in parallel with the cells at full load, and at light load one or more pairs of brushes may carry the load, while the other pair is connected to the battery, and the voltage is raised to any amount for charging.

W. G. R.

---

444. *Single-Phase Motors.* **A. C. Eborall.** (Elect. Rev. 42. pp. 31–32, 67–68, 136–137, 172–173, 276–277, & 355–366, 1898.)—These papers are notes upon single-phase alternating current-motors. Single-phase motors are grouped under three broad divisions:—

I. Constant magnetic field-motors;
II. Alternating magnetic field-motors; and
III. Induction motors.

Under Class I. come synchronous motors, which, as is well known, require to be run up to synchronous speed by some external means before being switched on to the alternating mains. Attempts have been made to make synchronous motors self-starting by laminating the fields and by passing the supply-current both through them and the armature at starting, thus causing the motor to run up to speed as an ordinary series or shunt-wound motor. Synchronism having been attained, the line-current would be switched on the armature and the fields excited by a direct current. On account of the difference, often wide, between the self-inductions of the field and armature windings, the starting torque is but small.

At starting this motor belongs to Class II., of which but little is said, since a really good alternating magnetic field motor has not yet been produced. They all possess the disadvantages of having (1) low efficiency, chiefly due to the hysteresis and eddy-current losses; (2) large "no-load" current and low power factor; (3) heavy sparking, especially at starting and overloads; and (4) low weight efficiency.

In considering induction motors the author goes into details of the construction of the stator and rotor as well as into general theoretical considerations. The essential points in the design of induction motors are as follows:—

Firstly, both stator and rotor should be quite smooth all round, large polar projections on either being avoided.

Secondly, the air-gap must be only just large enough to permit the rotor to run freely with danger of touching the stator. As the no-load current and power-factor at all loads depend mainly on the size of the air-gap, it is clear that it must be as small as possible; also the larger the air-gap the greater will be the leakage.

Thirdly, the rotor currents must be confined to proper paths, so as to keep the heating losses as low as possible and to make the torque for a given current as high as possible.

Lastly, the arrangement of the stator winding and iron parts must be such that the leakage field is a minimum, otherwise there may be eddy currents in the motor-frame, and even in the stator-conductors themselves, causing loss of energy.

The information contained in these articles relating to the construction of motors is valuable, but the theoretical portions are sometimes rather vague. One of the disadvantages of the squirrel-cage rotor for motors is, the author states, that the motor is liable to burn out. This may be said to be a disadvantage of any motor, either of the direct or alternating current types. One thing is certain, and that is the induction motor with short-circuited rotor bars will stand a greater overload than any other type of motor without undue heating.

The following table shows the efficiencies and power-factors of single-phase motors made by Brown, Boveri & Co.

Horse-power	Approximate weight (in pounds).	Full-load efficiency (per cent.).	Apparent Watts per H.P.
0·1	40	50	2260
0·3	60	60	1750
1·0	140	65	1570
2·0	240	70	1420
3·5	400	73	1330
6·0	620	76	1240
9	1000	80	1150
13	1400	84	1080
20	1700	88	1020
35	3100	90	1000
45	4000	90	1000
65	5200	90	1000
90	6800	91	990

[*To be continued.*]

W. G. R

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

445. *Electrical Distribution on the Oxford System.* **J. H. McLean.** (Lightning, 13. pp. 75–77, 1898.)—The author discusses the special advantages of the Oxford system, and gives a brief account of some improvements in the method of working.

A. H. A.

---

446. *Line-effects in Alternate-Current Transmission.* **H. E. Raymond.** (Amer. Electn. 9. pp. 219–220, 1897.)—This article deals with some of the so-called line "effects," and the author is of opinion that in designing and laying out the line for an alternating-current transmission, all calculations must be based on the individual requirements of the case. The troubles are usually due to the prevalence of induction, electrostatic, and capacity stresses, these effects increasing greatly with its length. In the author's experience the most serious and troublesome effects have been those due to electrical resonance. It has been found that for every line there is a certain natural period of wave oscillation, just as there is in a bridge or floor, and if this electrical oscillation is such that the machine frequency will coincide with it, the resultant vibration may raise the actual voltage to a great extent. An instance is mentioned of a 3-phase line 4½ miles long, operating normally at between 2500 and 3000 volts, having voltages of from 3500 to 3700 volts developed in it due to resonance effects. One trouble due to this rise in voltage is that the normal spark-gaps of the lightning arresters have to be increased, and the risks on the plant due to a lightning discharge are consequently increased.

The author is of accord with Dr. Louis Bell that insulation on the wires themselves for an overhead line is practically useless. The only real use of overhead-line-wire insulation is in the protection of the line from falling branches and trees. It would probably be cheaper to make a considerable detour than to try to insulate the wires, so as to render them safe against short circuits and earths.

A few notes are given with regard to the dead-ending of wires on poles, and a sketch is given of a convenient and effective method of carrying this out. Regarding the advisability of having more than one line wire it is difficult to judge. If the continuous operation of the system was of great importance, and if the cost of a shut-down were great, while the power transmitted was considerable, it appears that two lines would be advisable if the country and climatic conditions were unfavourable. If the cost of the extra line would not be justified by saving the expense of an occasional shut-down, it seems advisable to so arrange the line that all the wires in service could be on one side of the arm and at such a distance from the pole that a man could with some safety work on the otherside. L. J. S.

447. *Electricity in Paper Making.* **C. F. Scott.** (Elect. World, 31. p. 274, 1898.)—The Cumberland Mills, near Portland, Me., U.S.A., are worked by power electrically transmitted from a waterfall 4 miles distant. Two 300 H.P. 2-phase generators, coupled to 48-inch Victor vertical turbines, supply current at 1100 volts to four transformers; these raise the pressure to 8000 volts for transmission on the 3-phase system to the mill, where the pressure is reduced by transformers to 400 volts for supplying 2-phase induction motors. Seven motors are in use for driving machinery etc., two of these being coupled to direct-current generators for electrolytic work. 250 H.P. is also transmitted by direct current at 500 volts from a waterfall 1 mile distant. The motors are subject to severe conditions, such as exposure to chlorine gas, dampness, and sudden stoppages, but they give no trouble. The efficiency of the plant is found to be about 76 per cent., from the B.H.P. of the turbines to that of the motors, and a marked saving is effected in comparison with steam power. A. H. A.

448. *Electric Transmission for Paper-making.* **L. Bell.** (Elect. World, 31. pp. 269–270, 1898.)—The author considers the chief use of electricity in paper-making to lie in the transmission of power from waterfalls, and states that with coal at $3·00 per ton it is more economical to transmit 500 H.P. or more by electricity from a distance of 15 miles than to use steam power. Electrical transmission is not only cheap, but also reliable; and the difficulty formerly experienced in automatically controlling the speed of turbines is now overcome. Assuming, for example, that a mill requires 1000 H.P. continuously, and that sufficient water-power is available 10 miles away, the author gives the following approximate estimate of capital cost:—

Three 500 kw. polyphase generators, wound for 6000 volts, erected complete........................	$30,000
Line for 10 per cent. drop, complete..	20,000
Step-down transformers for 1000 H.P.	5,000 to 6,000
Motors for 1000 H.P.	15,000 to 20,000
Total cost of electrical equipment, including station, say..............	80,000
Cost of water-privilege and hydraulic equipment, say	80,000
Total investment for 1000 H.P. day and night....................	$160,000

The running expenses are estimated as follows :—

Interest at 6 %, depreciation at 4 %, insurance and taxes at 2 %	$21,600
Labour	6,500
Stores etc.	5,000
Total annual cost of 1000 H.P. day and night	$33,100
Cost per horse-power year	$33·10

Using steam-plant of first-class quality, with coal at $3 per ton, the cost per horse-power year would be $50 ; the saving therefore amounts to at least $15,000 per year.

Electrical heating of the drying rolls etc. is impracticable, on account of the great expenditure of energy involved ; the author suggests the use of producer-gas for this purpose. A. H. A.

---

449. *Power Transmission in Montana, U.S.A.* (Amer. Electn. 10. pp. 51–55, 1898.)—An illustrated description of the plant to be used for transmitting about 4000 H.P. from a generating station on Big Hole River to the city of Butte, Mont., a distance of 20·6 miles. Four 66 in. double turbines, each developing 1200 H.P. at an effective head of 60 feet and a speed of 180 revs. per min., furnished with Lombard water-wheel governors, are to drive four 3-phase generators of 1000 H.P. each, delivering current at 800 volts to 12 step-up transformers (air-blast type) of 250 kilowatts each, the power being transmitted at 15,000 volts. The line consists of six No. 1 B. & S. gauge conductors, forming two three-wire circuits, and carried by porcelain insulators of the double-shed type supported on 10 ft. 6 in. cross-arms fixed to poles of Oregon fir. The poles are spaced 105 ft. apart. A cross-arm above the conductors carries three glass insulators, on which is strung a triple barbed-wire lightning-protector, glass being used for supporting the (earthed) barbed wires, in order to prevent friction and consequent breaking. The periodicity is 60. A. H.

---

450. *Accumulator Installation at Fribourg.* **R. B. Ritter.** (Électricien, 15. pp. 129–135, 1898.)—The electrical generating plant of the State of Fribourg, which has replaced the original teledynamic installation, is driven by water-power obtained from the River Sarine, and supplies electrical energy on the three-wire direct-current system to the town of Fribourg, distant about 1500 m. Two turbines are used, driving four Thury dynamos with a total capacity of 500 kw. ; there are two distribution networks, one for motor supply at 700 volts across the outers, and one for lighting at 300 volts across the outers. In order to cope with an increase in the demand, two batteries of accumulators have been installed in the cellars of the Town Hall, where also the feeders and mains terminate. The cells are of the Theryc-Oblasser type, each plate being enclosed in a sheath of perforated celluloid,

which supports the active material in place. There are 83 elements in each battery, having a capacity of 2600 ampere-hours at a discharge rate of 130 amps., or 1400 amp.-hrs. at 400 amps., with a fall of pressure of 10 per cent. Each element consists of 50 plates, 250 mm. × 200 mm., contained in two glass cells, and weighing 138 kg. in all. As the maximum pressure obtainable from the lighting generators is 175 volts, a number of the cells are cut out of circuit when the main batteries are charged; these cells are separately charged by means of a 50 H.P. Lundell motor run off the 300-volt circuit, which drives two charging dynamos. The latter are protected against reverse currents by Alioth automatic switches, of which a description is given.

The discharge is regulated by the Trumpy system of automatic gear; relays connected by pilot-wires with the distributing network actuate regulating switches, which cut out or add cells as required to keep the pressure constant. Diagrams of connections are given, with a description of the apparatus. A. H. A.

---

451. *Worm-Gearing for Traction Motors.* (Amer. Electn. 10. pp. 81–82, 1898.)—The advantages claimed for worm-gearing, as opposed to spur-gearing, are:—(1) That the former allows the use of high-speed, and therefore lighter and cheaper, motors; (2) the motor can be at a distance from its driven axle, on which only the weight of the worm and gear need bear directly; in the case of a double truck, the motor driving one axle can be supported on springs over the other axle; (3) the saving in cost on the smaller motor would allow of wrought-iron magnets and laminated pole-pieces, thus increasing the torque; (4) greater clearance can be obtained between the motor and the road-bed; (5) since worm-gearing is not a reversible combination, it forms an efficient brake when current is cut off; (6) repairs to small motors are easier and cheaper. The one disadvantage noticed is that a disabled car can not be towed without detaching the worm-gear.

The author suggests rolling friction as a possible improvement in worm-gearing, and predicts that double-reduction gearing, which superseded the more efficient single-reduction gearing, will in turn give place to worm-gearing, the loss in efficiency being outweighed in both cases by advantages gained in other respects.

E. H. C.-H.

---

452. *Motor Cars on Railways.* **B. Tromieu.** (Écl. Électr. 13. pp. 260–264, 1897.)—The author gives some account of the motor cars employed by the Compagnie du Nord on their railway for postal purposes or when the traffic is very light. The cars are either steam or electric. A steam car has been in use for some time; it is fitted up according to the Serpollet system, and requires practically no attention, so that a single driver is all that is required. Twelve seats are provided for passengers. The weight is nearly 15 tons. This car is used for the postal service between Beauvais and Creil. In running from Paris to Beauvais with two

trailers, the total weight of train being about 36 tons, the consumption per kilometre amounted to 2½ kilogrammes of brickets and 9½ litres of water: the mean speed, excluding the one stop which was made, was 46·2 kilometres per hour.

The electric car is 14½ tons in weight complete. It carries a single direct-driving motor of about 20 H.P., and a battery of accumulators 3·8 tons in weight. The battery, which consists of forty cells made by the Société pour le Travail Électrique des Métaux, is carried beneath the truck and can be easily removed. A car capable of carrying fifty persons is also contemplated: in this case the total weight will be 24 tons, the battery amounting to 5½ tons. W. R.C.

---

453. *Accumulator Tramway Traction at Ostend.* **E. Piérard.** (Électricien, 15. pp. 135–136, 1898.)—Experiments are being made at Ostend on the propulsion of tramcars by means of accumulators of the Marschner type; these are made with a special paste, which gives the plates the necessary porosity together with great solidity. The battery consists of 96 cells in 12 sets, weighing in all 2600 kg.; each cell weighs 27 kg., and has a capacity of 400 ampere-hours, or 14·8 amp. hrs. per kg.

A car fitted with this battery has made several journeys, including one from Ostend to Ypres and back (147 km.), at a mean speed of 26 km. per hour; the current varied between 40 and 60 amperes, or 1·4 and 2·2 amps. per kg. The car has also travelled from Ostend to Blankenberghe and back (42 km.), towing loaded trucks. On account of the large capacity of the battery, a single charge would suffice to propel a tramcar for a daily run of 150 km. So far the battery shows no signs of wear and tear; but it remains to repeat the experiments under the ordinary conditions of tramway working, in order to ascertain whether the results given above can be maintained in practice. A. H. A.

---

454. *Contact Plough for Conduit Lines.* (Elect. Engin. 21. p. 20, 1898.)—A new plough is described which is lifted out of the slot in case of obstruction in the latter. The plough is suspended from levers pivoted on the frame of the car, in such a way that it is held in a vertical position. One of these levers is connected with a bar for raising the plough by hand; the second lever is connected with a spring by a link, which engages with a stop when the plough is down. Two trip-levers are provided, either of which, on meeting with an obstacle, releases the catch, and allows the spring to raise the plough clear of the slot; these levers also protect the plough from injury. A. H. A.

---

455. *Three-Phase Traction at Neuchâtel.* **R. B. Ritter.** (Ind. Élect. 6. pp. 470–472, 496–500, and 520–523, 1897.)—An account is given of the transformation of the horse-tramway (originally worked by gas) from Neuchâtel to Saint Blaise into a trolley line. The distance is 5 kilometres (3·1 miles). Various systems were

considered before coming to a decision. Three-phase current was available from the mains of Neuchâtel at a price of 195 francs (£7 16s.) per H.P.-year, and at a pressure of 4000 volts. The firm of Alioth recommended the use of rotary transformers giving a continuous current at 550 volts, to be worked in conjunction with a storage battery. The estimated difference in cost by the use of a battery is given below:—

	Half-hourly service.		Twenty-minute service.	
	Without accumulators.	With accumulators.	Without accumulators.	With accumulators.
H.P. required	50	20	60	30
H.P. taken up by battery	......	30	......	30
Total	50	50	60	60
Capital outlay in Station, in francs	19,100	31,100	20,000	35,900
Cost of working, in francs	11,160	9,600	13,100	11,300

Two other systems were considered, viz., a steam-plant, including two 60 H.P. engines and dynamos; and a Dowson gas-plant, including two 35-H.P. gas-engines and dynamos, together with a battery of 60 ampere-hours capacity. The estimated outlay and working expenses of the three systems are as follows:—

	Capital outlay on Station, in francs.		Annual working expenses, in francs.
1. Three-phase plant	35,900+14,000	(building)	14,590
2. Steam plant	63,500+20,000	„	24,960
3. Dowson gas-plant	69,300+20,000	„	23,866

The three-phase system thus appearing to be the most economical, it was adopted, and plant was erected sufficient to allow a regular service every half hour by running a car and a trailer from each end of the line, and also an intermediate car upon part of the line. On holidays a twenty-minute service is required.

The three-phase current at 4000 volts is first transformed down to 337 volts, and then, by means of the rotary transformers (two in number), into continuous current at 550 volts. The latter are 40 kilowatt machines. Economy in starting them up is effected by the use of subdivided three-phase transformers for that purpose. By this means a low pressure is at first applied and gradually increased as the machine gets up speed. The battery consists of 300 Tudor cells, and is fitted with an automatic regulator. In order to obtain the pressure necessary for charging the whole battery, a third small rotary transformer is used, the E.M.F. of which is readily adjusted so as to complete the charge of cells which have to be cut out of circuit during the times of charging by the other machines. The rails are bonded, and a bare 7 mm. wire is also placed in the ground and attached to the rails every 50 metres. The cars, constructed by the Société Industrielle Suisse of Neuheusen, are each provided with two Oerlikon motors of 12 H.P. (85 °/₀ efficiency). W. R. C.

456. *Street Sprinkler for Electric Tramways.* (Elect. Rev. N. Y. 32. p. 115, 1898.)—A new type of sprinkler by the Miller-Kniblock Co. is described. Two electrically-driven pumps at either end of the car force the water through four sprinklers at the corners. A lever at each end regulates the force of the spray, which can thoroughly cover a street 100 feet wide. The capacity of the sprinkler is 2500 gallons of water, all of which can be thrown to the full distance. E. H. C.-H.

457. *Rail Driller.* (Lightning, 13. p. 88, 1898.)—A description and illustrations are given of the 'Paulus' and 'Buda' drills introduced by Messrs. Laing, Wharton & Down, Ltd., for drilling rails *in situ*, by which it is claimed that a $\frac{7}{8}$ in. hole in a 90 lb. rail can easily be drilled in two minutes. The machines are of the 'monkey' type, power being applied to handles by two operators standing, and transmitted to the ratchet-fed drill by two sets of bevel gear. The upright which carries the driving shaft is supported from a sole-plate by rule-jointed stays. In the tramway pattern, the drill is held up to its work by two hooks over the head of the rail, and to allow trams to pass over, the upright is folded back, thereby slackening the hooks which are then swung off the rail. For main line express traffic a special type is made with hooks to pass beneath the rails. E. H. C.-H.

458. *Electric Lighting for Profit.* **A. Dow.** (Elect. Rev. N. Y. 32. pp. 94–95, 108, and 124, 1898.)—This is a paper on the commercial aspect of electric lighting stations. It is summarised as follows:—(1) The electric lighting business should pay, as a reasonable profit, approximately the same rate as any manufacturing business which has similar risks. This profit should be paid after the expenses of operation, maintenance, and depreciation, shown by annual inventory, have been provided for. (2) Rates for electric supply should be so adjusted that each unit sold will pay its share of operating and standing charges, and in addition a uniform proportion towards profit. No business should be done at a loss, and no business should pay more towards profit than its proper share. (3) Every class of business that can be profitably done should be obtained. Business that improves the load factor should be taken if it can be obtained at any price greater than its share of operating and standing charges, because the improvement of the load factor reduces the amount of standing charges to be borne by the existing load. (4) Business once obtained

should be kept by careful study of and prompt attention to the requirements of each customer. It is not possible in the present stage of electric development for an electric supply company to limit its interest in the supply to its delivery on the customers' premises. It must do much work in order to secure that the customer uses the supply to the best advantage. It is not sufficient that a customer should be well served; he must also be well pleased. (5) There is need of educational work to be done among electric light men, among municipal authorities, municipal theorists, and among customers. W. G. R.

---

459. *Gas-driven Lighting Plant.* (Elect. Engin. 21. pp. 6–10, 1898.)—In this article a description of the electric lighting plant of the Midland Railway Company at Leicester, and a statement of the results obtained, are given. The installation includes 113 10-ampere arc lamps in 7 series circuits, 28 arc lamps run 2 in series on the low-tension circuits, and 320 incandescent lamps ranging from 8 c.p. to 32 c.p. at 110 volts.

Three 50-light Brush arc-lighting dynamos and three low-tension dynamos are installed, the total capacity being about 137 kilowatts; a Sayers compensator, consisting of a series-wound generator driven by a shunt-wound motor, is used to compensate for the loss in the low-tension feeders. The arc circuit switchboard is specially designed to dispense with the use of flexible cords and plugs, by means of a system of panels with dynamo and lamp circuit contacts on each, and movable switch bars to make the connections.

The dynamos are driven by gas-engines using Dowson gas, and provided with special lubricating devices for continuous running; gas can also be obtained in case of need from the town mains.

There are two complete sets of Dowson generators, in which anthracite coal is used. Formerly the consumption of coal amounted to 4·6 lbs. per Board of Trade unit, but by using small coal (which is also cheaper) and a shallow fire, the quality of the gas has been greatly improved, and the consumption of coal reduced to 3·03 lbs. per unit.

The detailed costs of working for the half years ending June 30th, 1896 and 1897, are given below. These figures include the cost of town gas; it is stated that if none of the latter were used the cost per unit would be reduced to 2·67*d.*

	1896.	1897.
Arc lamps in use	137	141
Incandescents	288	320
Total units	126,514	137,070
Total cost	£1,631 9*s.* 1*d.*	£1,604 15*s.* 9*d.*
Total cost per unit	3·09*d.*	2·8*d.*
Labour per unit	1·42*d.*	1·49*d.*
Stores and carbons	1·19*d.*	·86*d.*
Repairs	·13*d.*	·16*d.*
Coal	·32*d.*	·18*d.*

A. H. A.

460. *Charging for Electrical Energy.* **G. Claude.** (Ind. Élect. 6. pp. 465–470, 1897.)—The author at first deals generally with the encouragement of the use of current for other purposes than lighting so as to improve the load curve; and then passes on to the question of tariff. The Wright system fails in the case of consumers who use their light for only a short part of the year. These, owing to the small number of units which they consume, do not pay a sufficient sum to compensate for the fixed charges incurred in meeting their demand. This defect would be overcome if the Wright indicator showed the amount due for fixed charges, instead of the maximum demand. Some customers would, however, object to the payment of a lump sum. The Wright system also fails in that it makes no distinction between two consumers having the same maximum demand but who differ widely in the number of units consumed. It would be preferable to have a discount system to come into force after a customer has consumed the requisite number of units at the full price. The author proposes in the first place to charge a certain sum depending on the maximum demand; this charge, however, being lower in proportion as the demand is greater, otherwise large consumers would be discouraged. Thus the charge per kilowatt demanded might be expressed by the following formula

$$p=\frac{a}{x+b},$$

and the total charge on this account would be $\frac{ax}{x+b}$, in which a and b are constants, and x the maximum demand. In the second place, the price per unit should grow less as the consumer increases his consumption or load factor, apart from the question of maximum demand. Hence the price per unit should be of the form:—

$$p=\frac{a_1}{f+b_1},$$

in which a_1 and b_1 are constants, and f is the mean load factor of the consumer. The number of units consumed in time t is tfx, and thus the amount due on that account is $\frac{tfx}{f+b_1}$. The total price per unit is, of course, the sum of the two charges. Such a method of charging would lead to an increased use of current in hours of daylight and thus a larger load factor for the supply station.

W. R. C.

TELEGRAPHY AND TELEPHONY.

461. *Cable from Fire-Island to Conklin's Point.* (Elect. Rev. N. Y. 32. pp. 102–103, 1898.)—Sighting towers have recently been established outside New York, by the American Postal Telegraph-Cable Co., for the purpose of reporting shipping. The terminal tower on Fire Island now communicates by land lines, and a cable in Great South Bay, with Brooklyn, New York, and intermediate stations. The cable contains six cores, in three pairs, insulated with okonite; it is sheathed with galvanised iron wire. Its total length is six statute miles, diameter 1·75 inches, total weight 65 tons. Owing to the shallowness of the water, the shifting shoals, and the sand-bars in the Bay, some care was necessary in laying the cable. The method was to coil it on the flat bottom of a barge, and then to pay-out under a sheave astern, piloted by a small-draught tug. R. A.

462. *Switchboards for Private Telephones.* **Mandroux.** (Électricien, 15. pp. 97–101, 1898.)—The author classifies the systems into those using (*a*) two cords and (*b*) one cord; the former group is described under two headings, (*a*) independent cords, (*b*) fixed cords. M. OG.

463. *Switchboards for Private Telephones.* **Mandroux.** (Électricien, 15. pp. 122–125, 1898.)—One act of plugging completes a connection in monocord boards. Economy is gained by using positive and negative call currents with a reversing key. The operator knows the goodness of each line by hearing her own call current (partly shunted). M. O'G.

464. *Series-Multiple Telephone Board.* **K. B. Miller.** (Amer. Electn. 10. pp. 32–33, 1898.)—A very clear diagram shows all connections. The repetition at each operator's section of all the jacks is necessary, and at each repetition the continuity of the line depends on a dusty contact. The connection of two subscribers detaches one of the twin wires from a capacity—that of the drop and switchroom wires. Both these evils are overcome in the Branch Multiple Board. M. O'G.

465. *Branch-Multiple Telephone Board.* **K. B. Miller.** (Amer. Electn. 10. pp. 82–83, 1898.)—One diagram of details and one of principles are explained. 'Branch' systems with 3 wires and auto-restoring drops are superseding the series board. M. O'G.

466. *Telephone Line Protectors.* (West. Electn. 22. p. 124, 1898.) —The air-tight iron end-box of air-space cables bears for each wire a lightning arrester of two carbons separated by perforated mica 0·005" thick. To guard against heavy currents each carbon encloses a metal ball imbedded in fusible wax which melts and short-circuits the guard. Besides, each circuit includes a german-silver heat-coil which melts an alloy and closes a "sneak-circuit," calling attention to the break. Also a 5-amp. fuse sealed in a wooden tube protects the cable. A round poletop box containing quicklime is shown. A carbon and ball arrester and heat-coils are used at each subscriber's connection. M. O'G.

467. *Telephone Magnets.* (West. Electn. 22. pp. 131–132, 1898.) —Once the number of turns is fixed [electrical reasons not given] the core is designed to suit switchboard mechanisms. Up to six wires are spooled simultaneously to the same length and resistance and occupy the same relative position to the core. This "compartment" winding (by the Varley Duplex Co.) raises the insulation resistance from 50 megohms to 45,000. M. O'G.

468. *Telephone Apparatus.* **H. P. Clausen.** (West. Electn. 22. pp. 127–129, 1898.)—General connections are shown, and each element in detail. Standard sizes, windings, gauge of wires and designs are also given. M. O'G.

469. *Telephone Details.* (West. Electn. 22. pp. 120–121, 1898.) —At Fort Wayne, U.S.A., lead cables are encased in vitrified tiles bedded in concrete. Switchboard cords are protected with hard brass wire spirals and polished linen braid reinforced in the plug-heel. The chief operator may switch on to any subscriber to receive complaints. The board has a lightning arrester to each line. Any wire can be rapidly transferred from number to number at the permanent test terminals. M. O'G.

470. *Wires for Telephony.* (West. Electn. 22. pp. 134–135, 1898.)—Wires are coloured to match oak, mahogany, etc. Twins are distinguished by one raised thread in the braid by feeling only. Communication with a stranded ship is noted. M. O'G.